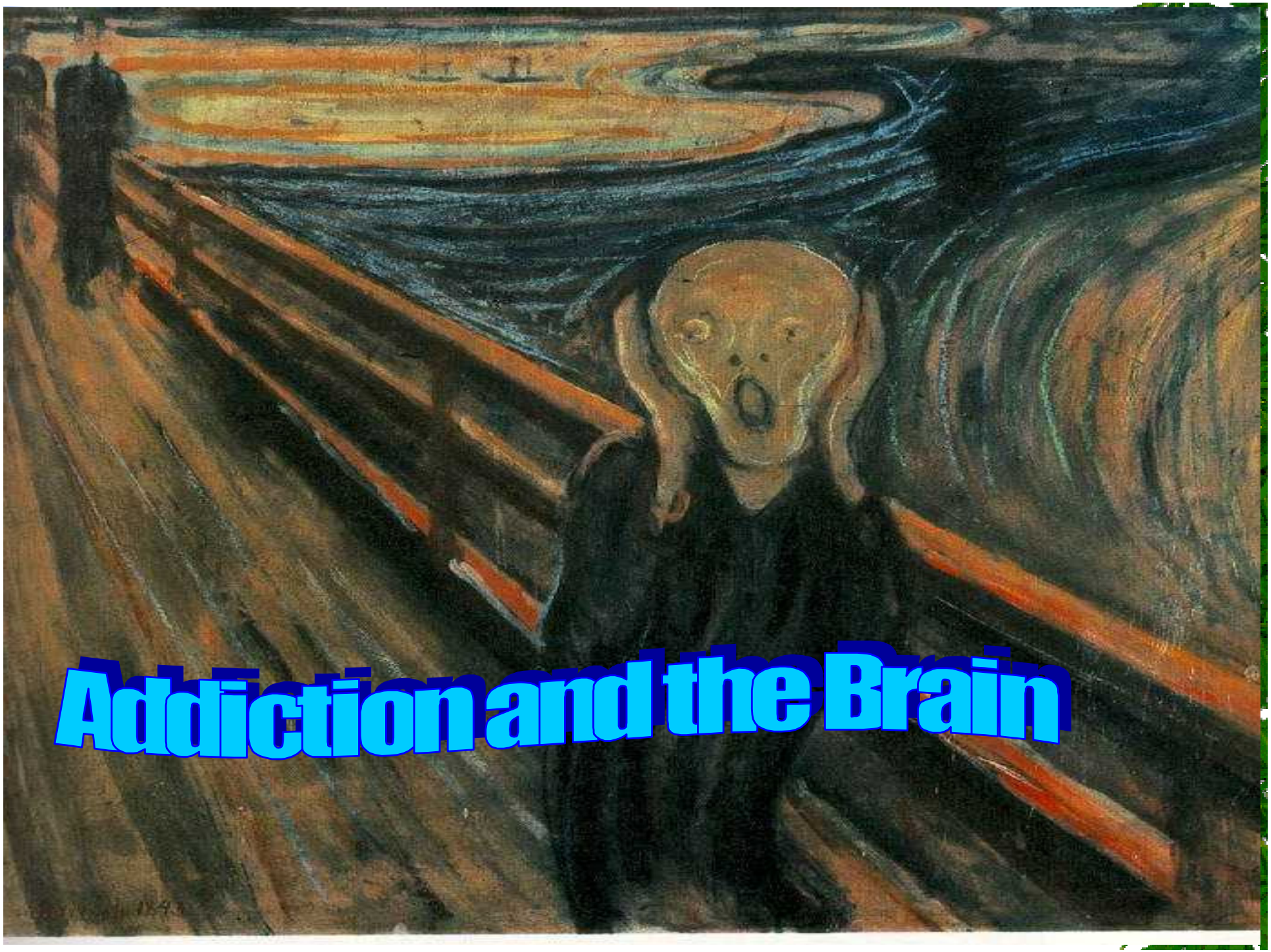

Addiction and the Brain

The Human Condition

- Drug abuse does not occur in a vacuum; we are all subject to influences beyond our control:
  - Genetic Propensities (up to 1/3 of all people)
  - Basic Neurochemical Makeup
  - Psychological Dispositions
  - Social Conditions
  - Existential *Angst* (sense of meaninglessness in life)

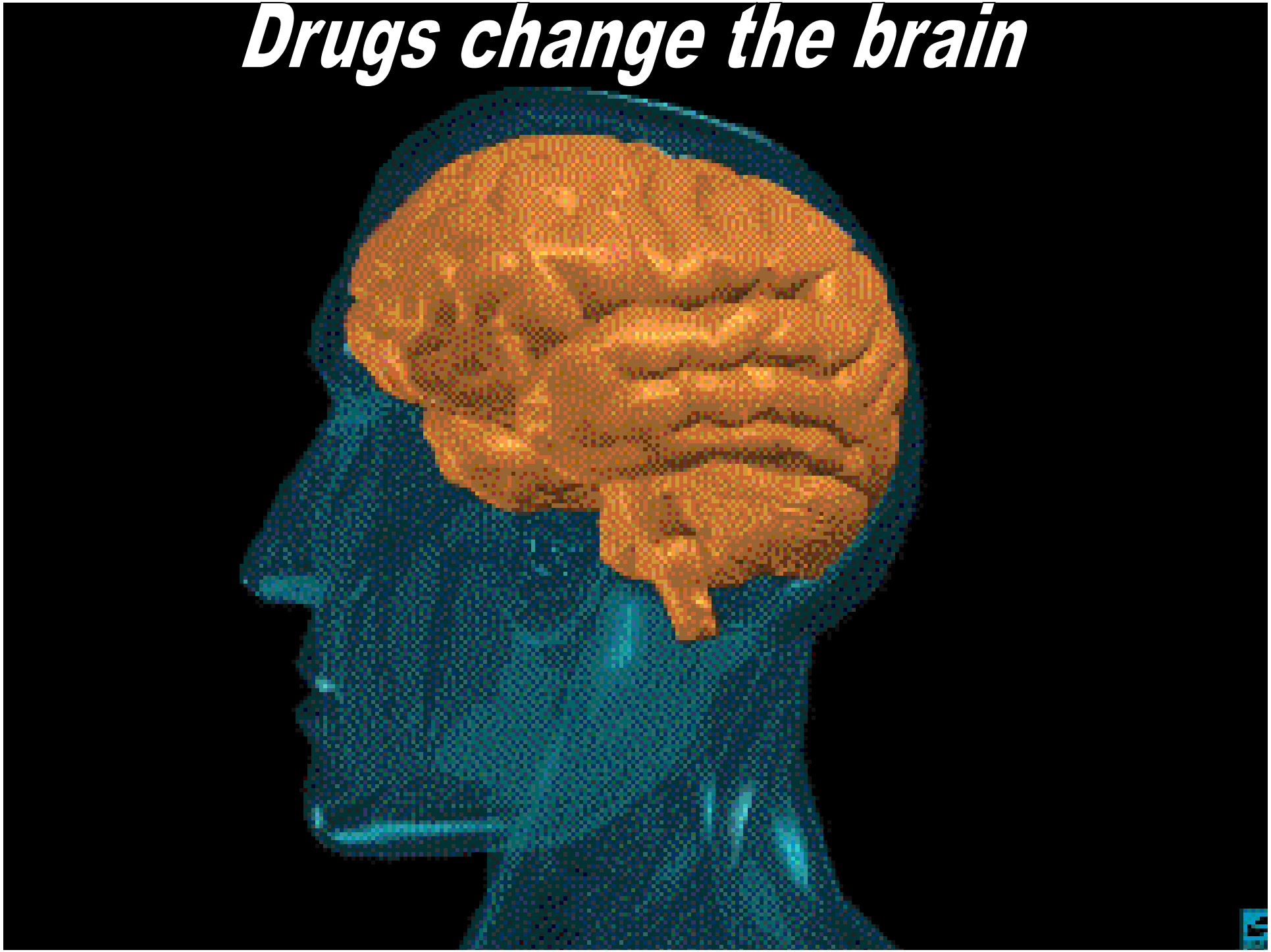
What is a Drug?

- "A drug is a pleasure producing chemical" (Alex Stalcup)
- "Drugs cause the chemical pathways in the brain to be activated or inhibited, producing pleasure or euphoria" (Alex Stalcup)
- People use drugs for one reason: <u>they work!</u>
  - *But the side effects destroy a person both physically and mentally.*

What is a person?

- A person cannot be reduced to simple biological, psychological, or sociological definitions.
- A person is more than the sum of her parts.
- Some of the more important dimensions of personhood are:
  - Biological
  - Psychological
  - Interpersonal
  - Spiritual

Drugs change the brain



How to understand addiction

- Addiction can best be understood as something that involves every dimension of a human being:
  - Biological (your body and brain)
  - Psychological (your mind)
  - Interpersonal (your social world)
  - Spiritual (your existence)

How to understand addiction (cont)

- Addiction involves all dimensions of who and what we are –it affects your entire life;
- You can't just keep it part-time or hidden away –drug addiction will eventually reshape your entire being biologically, cognitively, socially, and existentially.

Characteristics of Addiction

- Compulsion
- Continued use despite adverse consequences
- Craving
- Denial
  - Source: Alex Stalcup, MD

The Biological Processes of Drug Action

Neuroadaption

- Every drug of abuse actually causes the brain to reorganize on a cellular level;
- This process is called “neuroadaption” and is responsible for the long-term damaging effects of drug abuse on the brain.

Neuroadaption

- The “rewiring” of the brain has significant damaging effects:
  - Mood disorders
  - Memory problems
  - Anxiety disorder
  - Depression disorder
  - Bipolar disorder
  - Paranoid schizophrenia

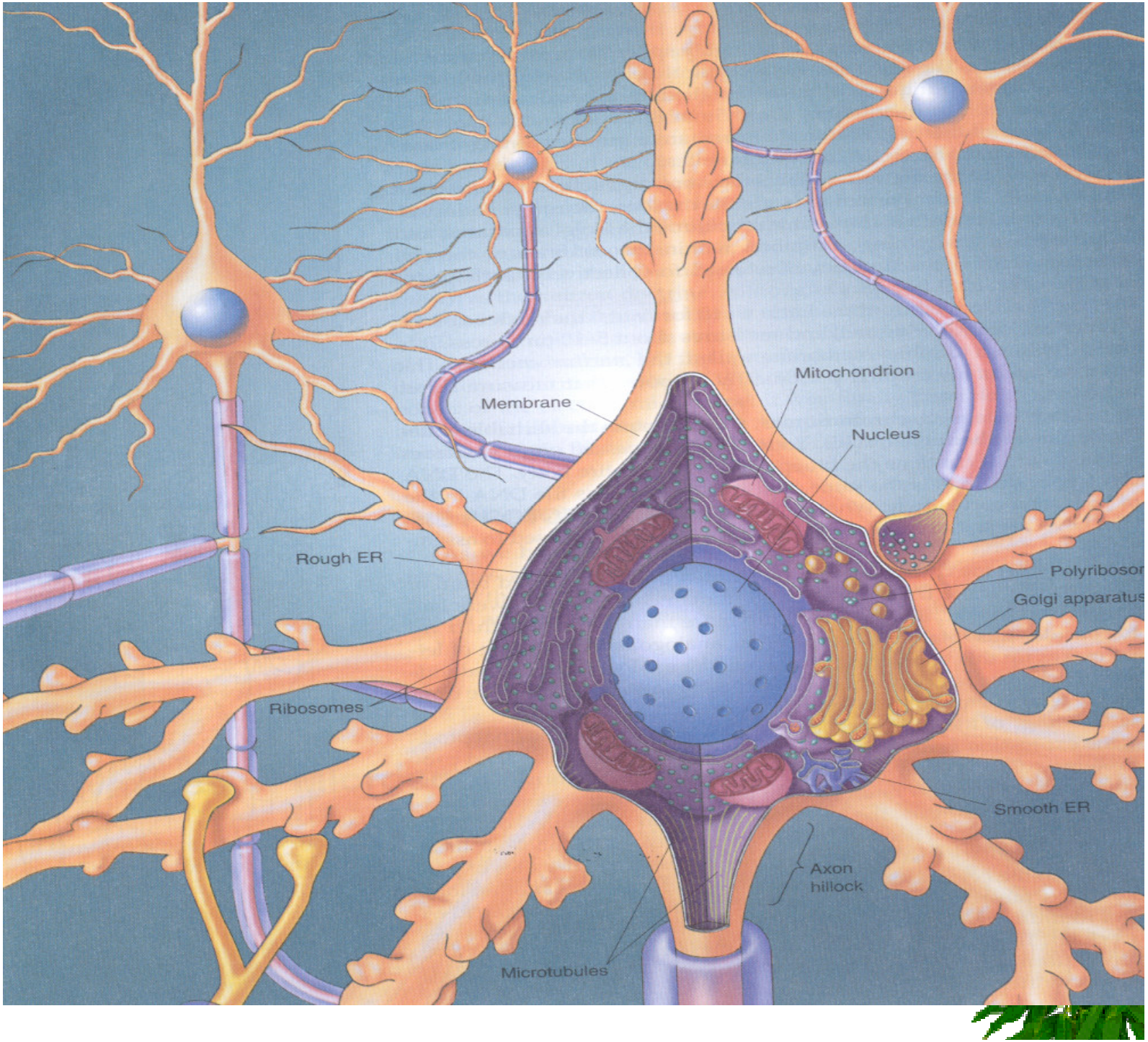
Neuroadaption (cont)

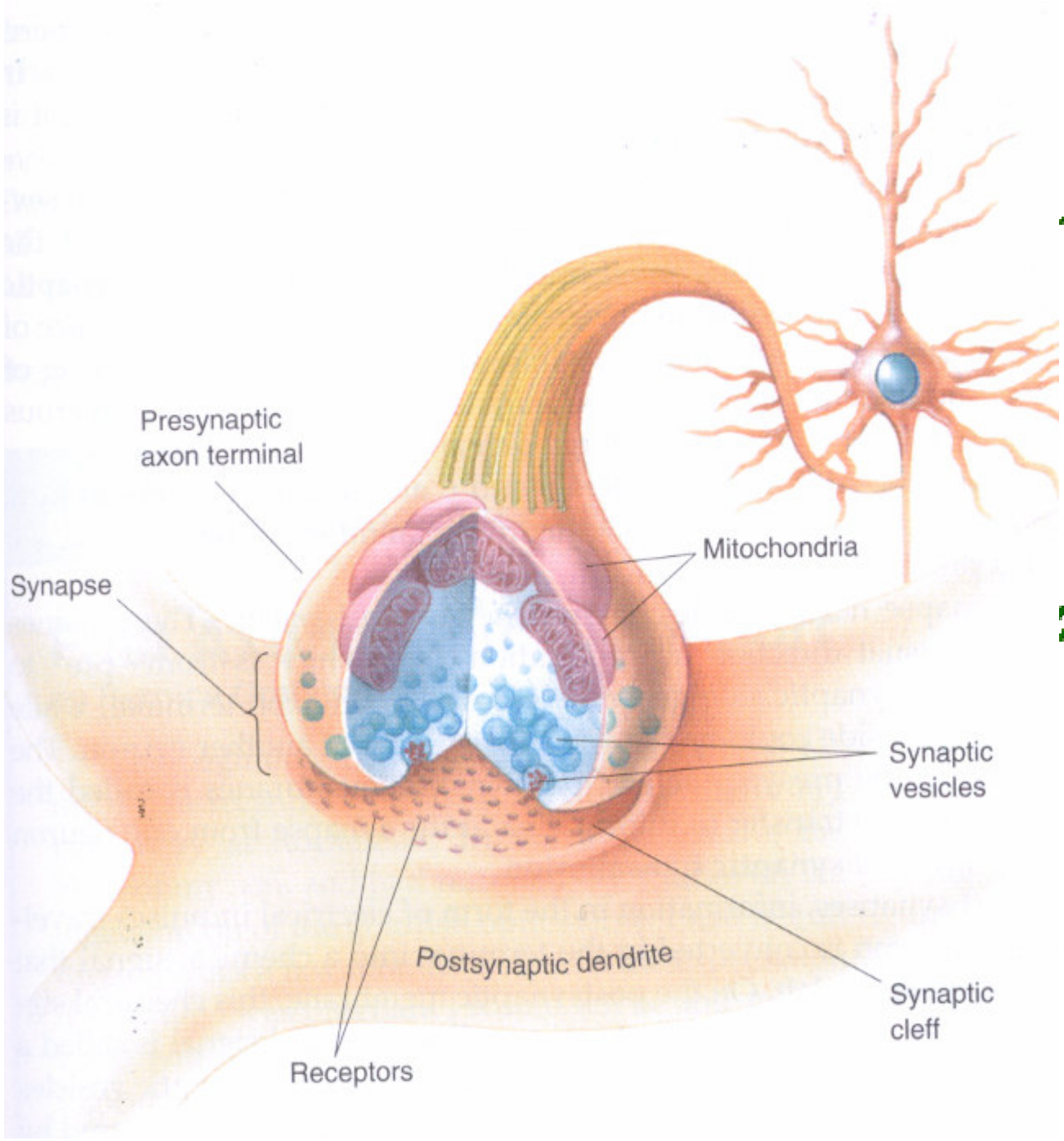
- The disorders that result from the brain's adaptation to drugs of abuse represent permanent brain damage that will persist even after discontinuing use of the drug.
- You never fully recover neurologically from drug abuse! You will ***never*** feel as good as you did before using drugs!

The Human Brain

- The human brain is very complex:
  - It consists of over 100 Billion brain cells (neurons);
  - Each neuron has (on the average) 5000 “synaptic connections”;
  - A synapse contains a chemical factory that sends messages across the “synaptic gap” to other neurons by releasing varying types and quantities of molecules (neurotransmitters);

Neuron Architecture




Presynaptic
axon terminal
Synapse
Mitochondria
Synaptic
vesicles
Postsynaptic dendrite
Synaptic
cleff
Receptors

The Human Brain (cont)

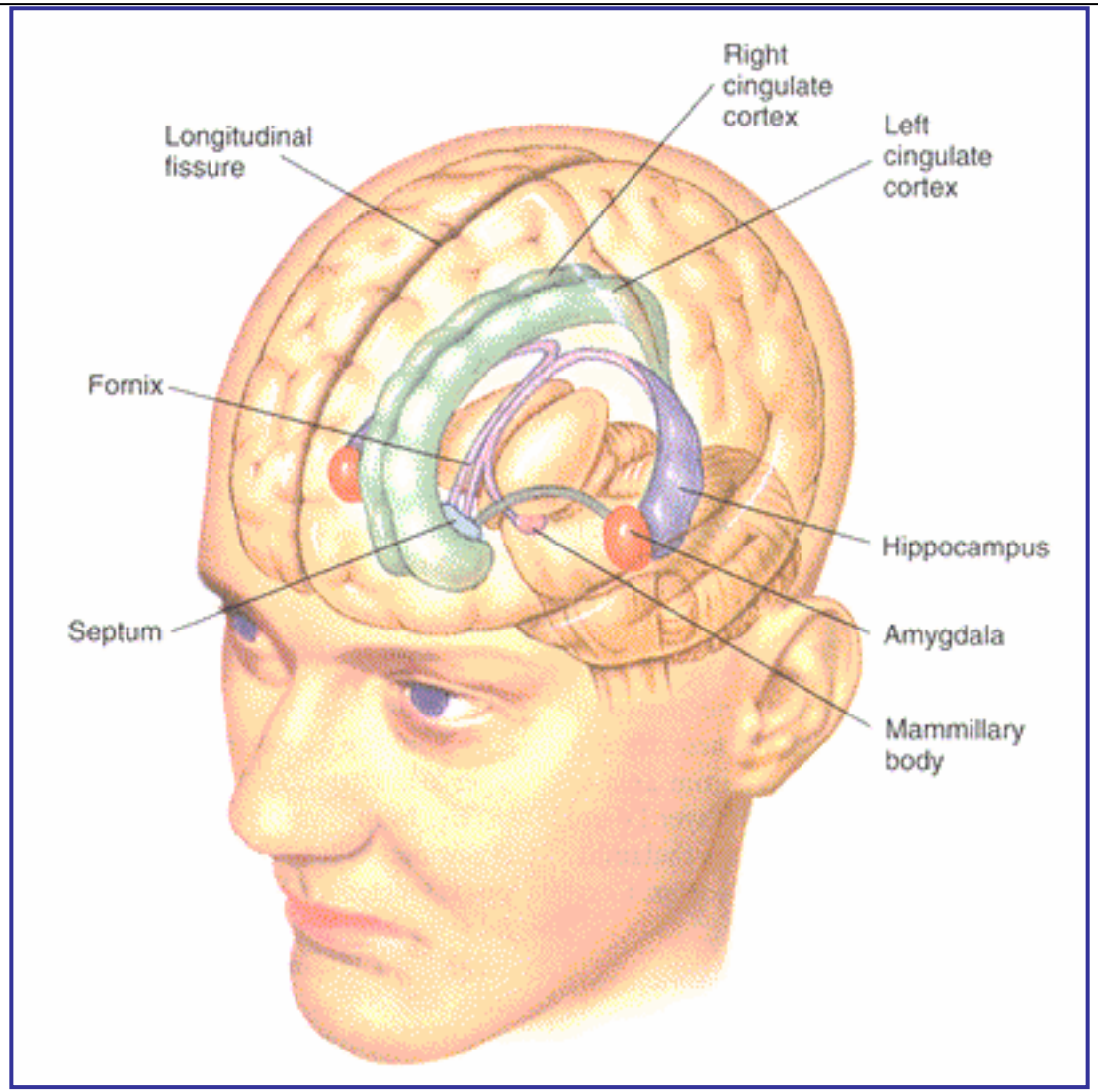
- There are hundreds of identified neurotransmitters, each causing a different cellular reaction in different degrees of intensity;
- Neurotransmitters are released in “pathways” that connect different parts of the brain through chemical stimulation;
- Drugs of abuse adversely alter the chemistry of these neurotransmitter pathways.
- These pathways are associated with cognitive functions.

The Monoaminergic Neurons

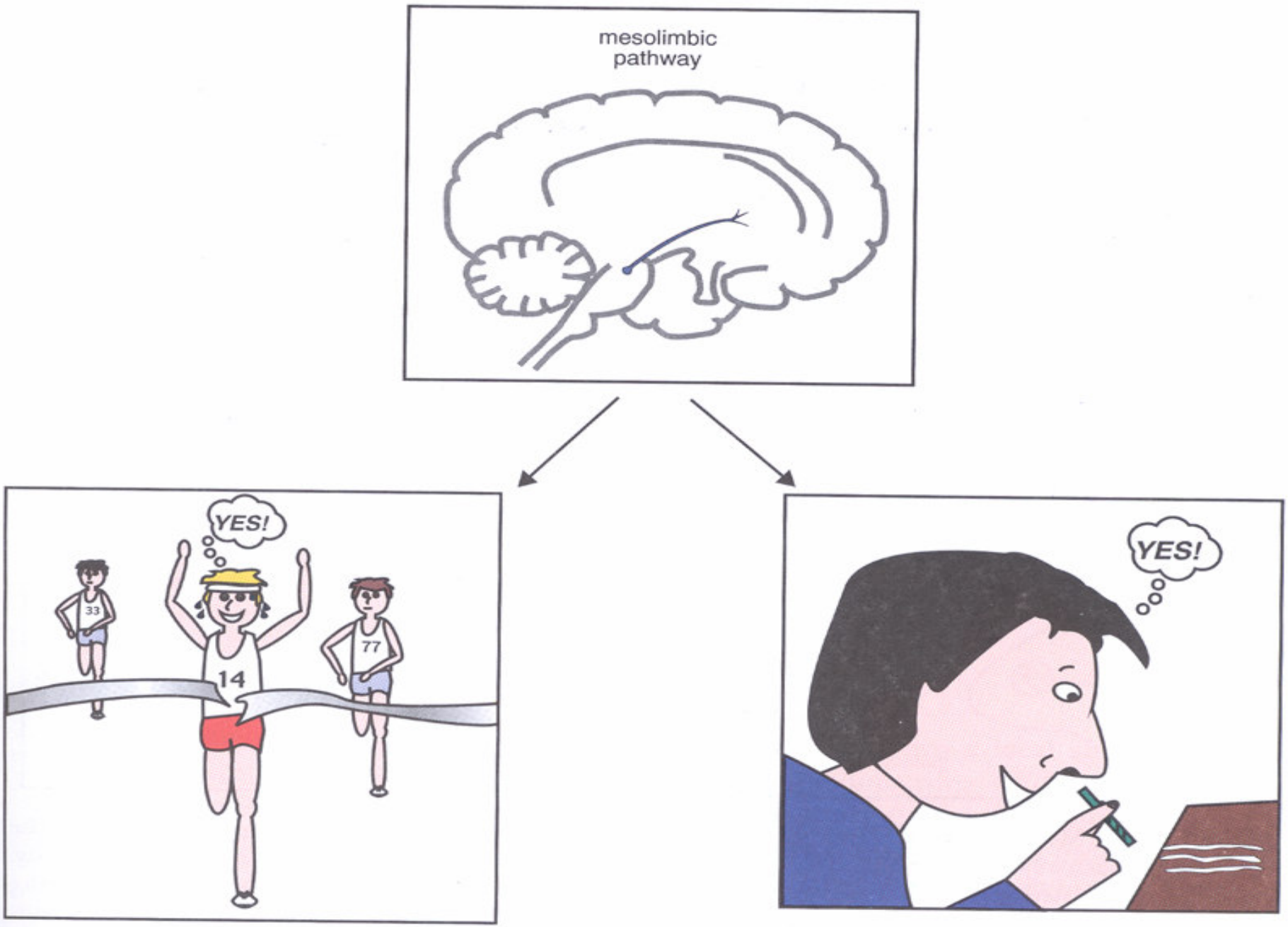
- Dopamine (DA)
- Serotonin (5HT)
- Norepinephrine (NE)

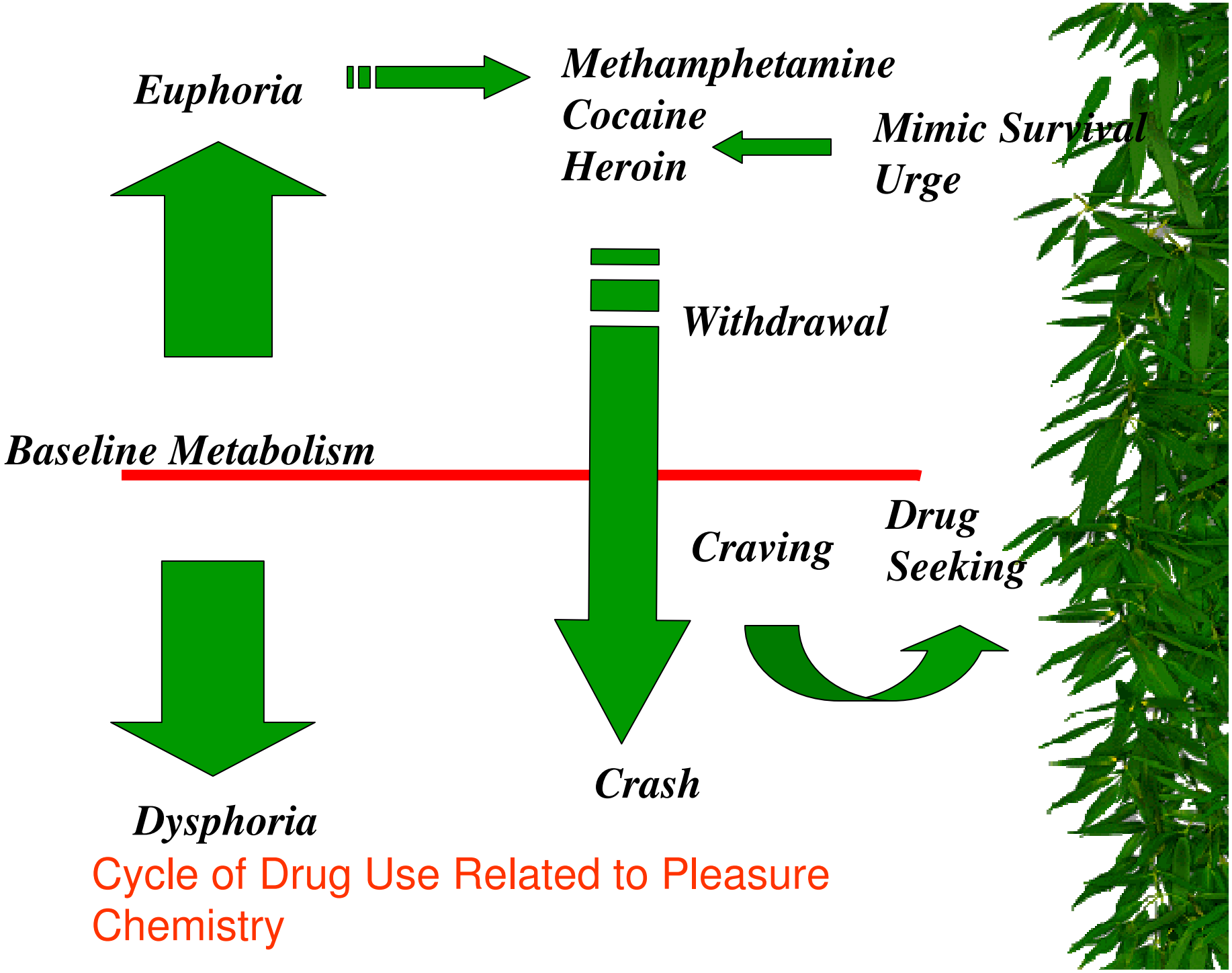
  - *This group of neurotransmitters are associated with stimulation, mood, pleasure, reward, excitement, dreams, and a sense of well-being;*
  - *They are parts of a family called "monoamines" and interact with each other.*

The Limbic System



Mesolimbic Dopaminergic Pathways


mesolimbic
pathway
YES!
33
14
77
YES!

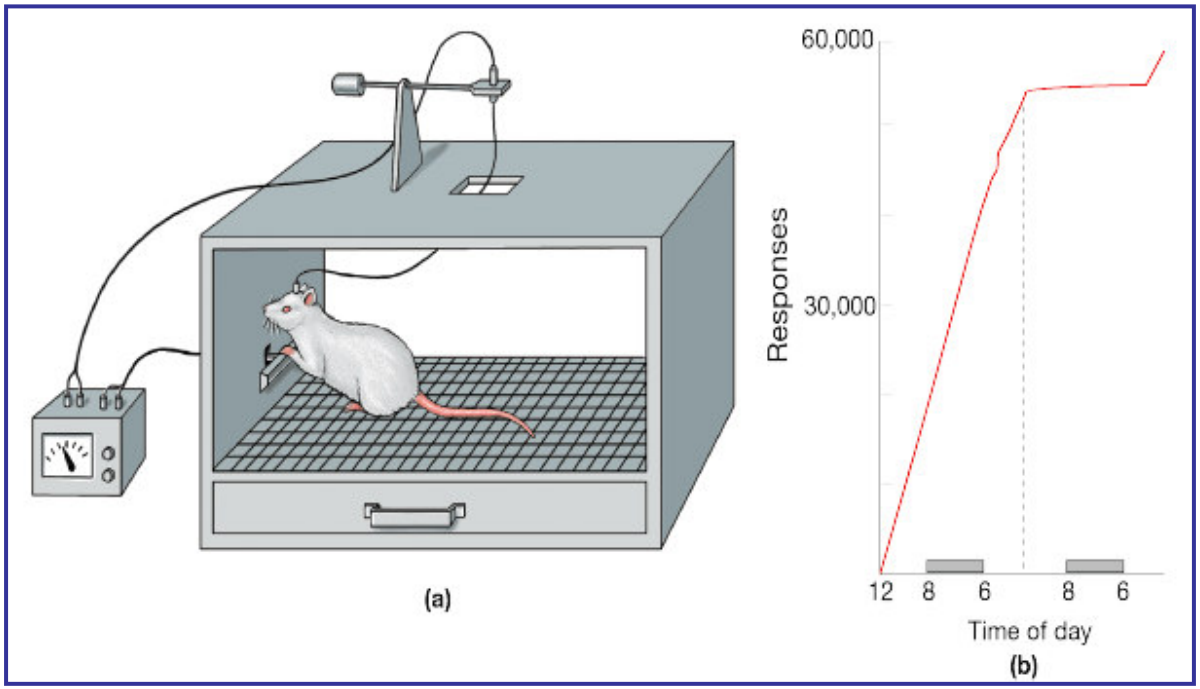


Cycle of Drug Use Related to Pleasure Chemistry

A Never-Ending Cycle

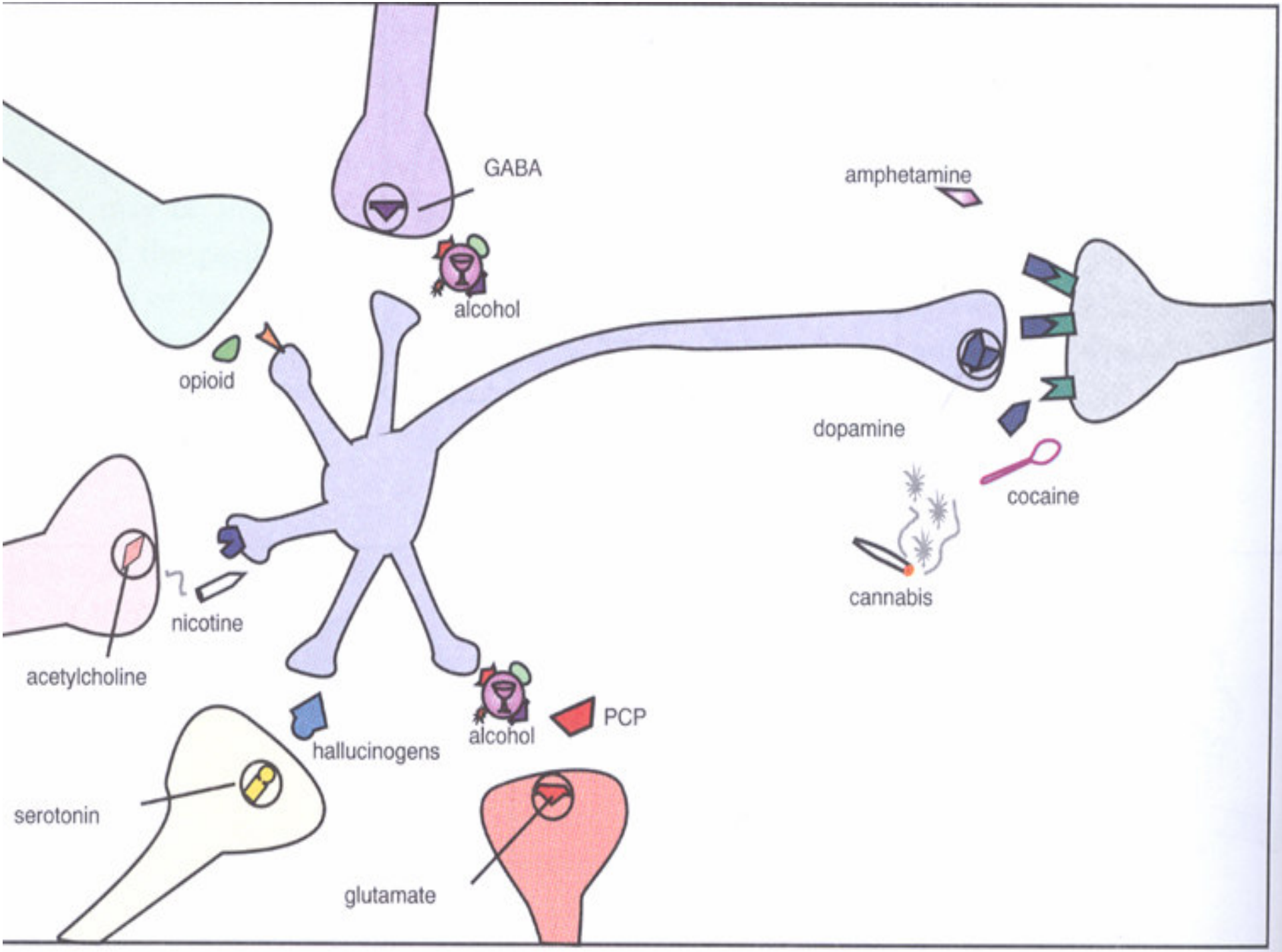
- The cycle of Neuroadaption and craving is a spiral that, if not interdicted, will lead to self-destruction and eventually death.

Self-stimulation or Self Administration of Drugs



Pleasure Chemistry

- Every drug of abuse relates in some way back to the brain's pleasure chemistry;
  - *All neurological activity of drugs of abuse will have an effect upon the norepinephrine, dopamine, or serotonin pathways within the limbic areas of the brain*--

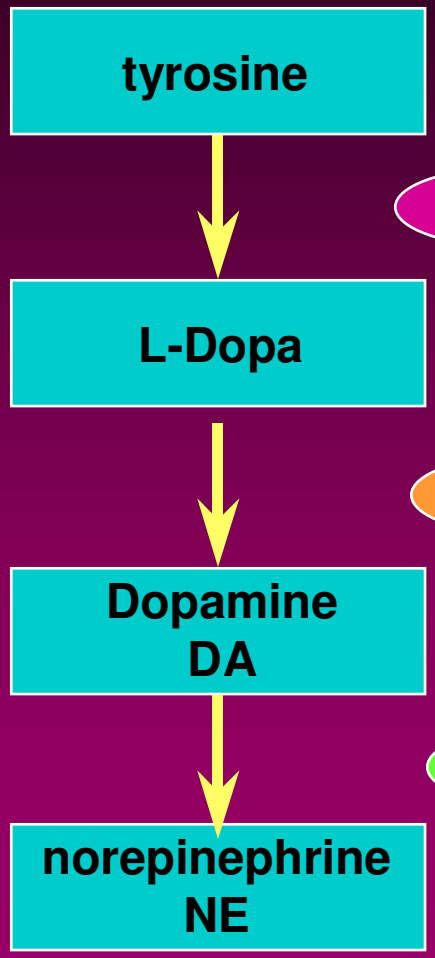

GABA
amphetamine
alcohol
opioid
dopamine
cocaine
cannabis
nicotine
acetylcholine
hallucinogens
alcohol
PCP
serotonin
glutamate

Neurotransmitters and Reinforcement

- It is hypothesized that cocaine and amphetamines act on both stages, whereas other drugs only act on one stage, possibly through endogenous opioid circuitry.
- The following neurotransmitters are thought to be involved:
- Monoamines:
  - Dopamine
  - Norepinephrine
  - Serotonin
- Neuropeptides:
  - Endogenous Opioids:
    - Dynorphin
    - b-Endorphin
    - Enkephalin

biosynthesis of DA and NE.....

precursor; common in many foods



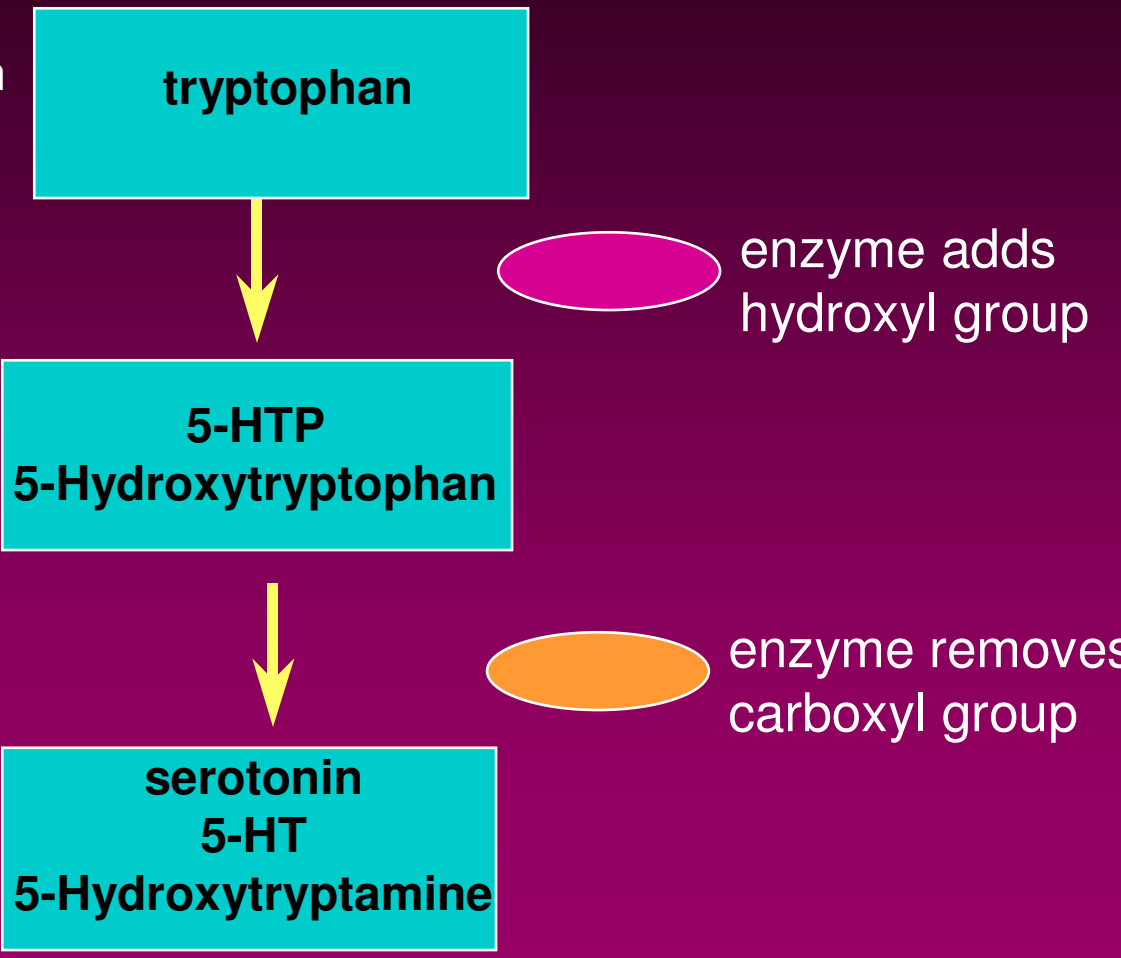
get L-Dopa - given to Parkinson's patients

get DA - final stage for DA neurons - too much DA implicated in schizophrenia

get NE - this part occurs in the terminal button in NE neurons

biosynthesis of Serotonin.....

precursor amino acid; common in dairy products



get 5-HTP

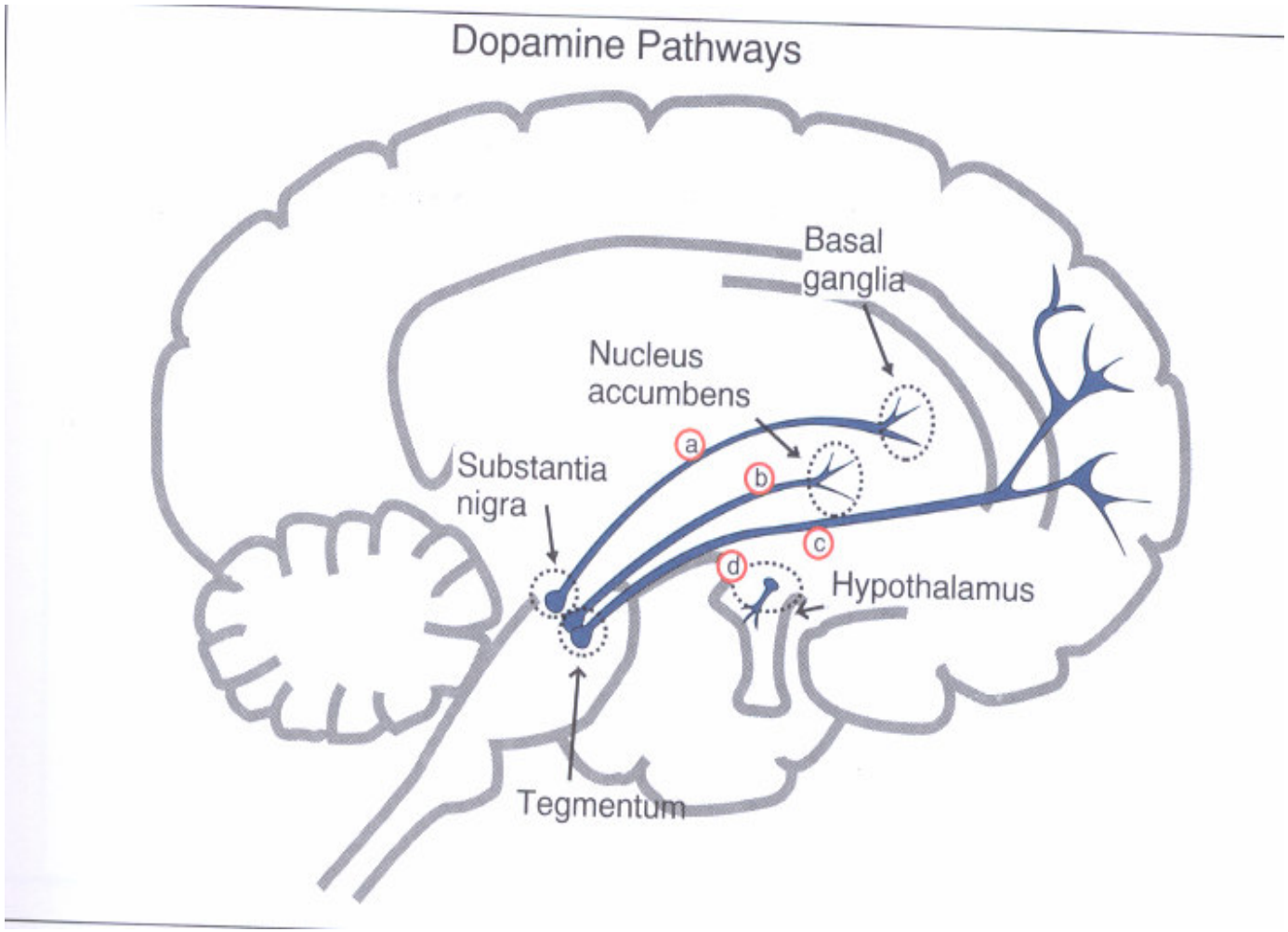
get 5-HT.

biodestruction of DA, NE, and 5-HT….

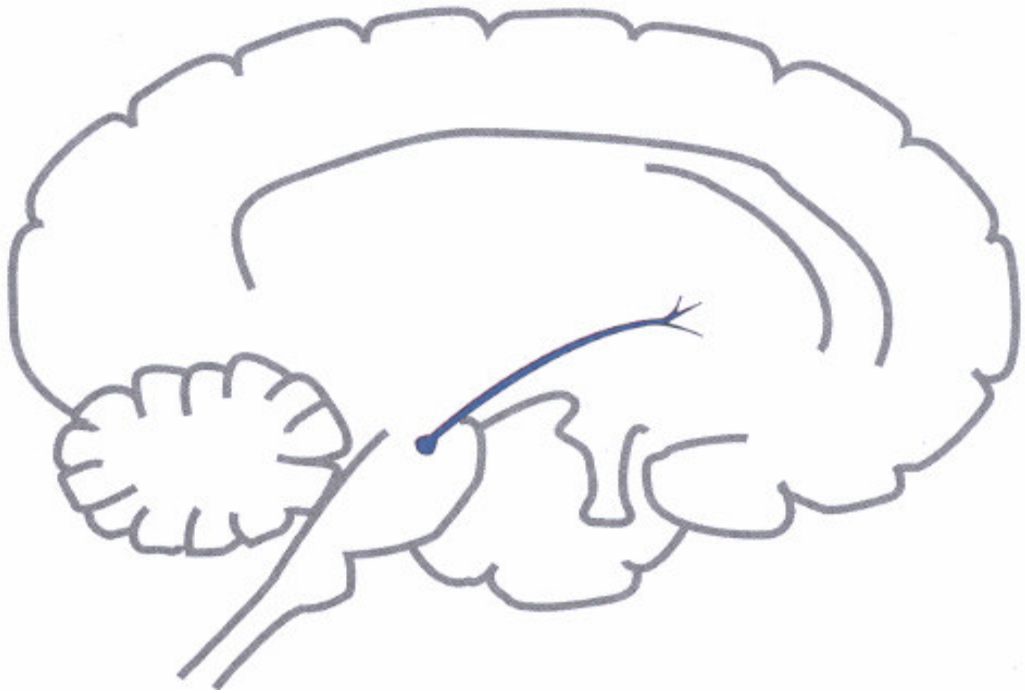
- dopamine, norepinephrine, and serotonin are destroyed by MAO
  - monoamine oxidase
    - found in synapse

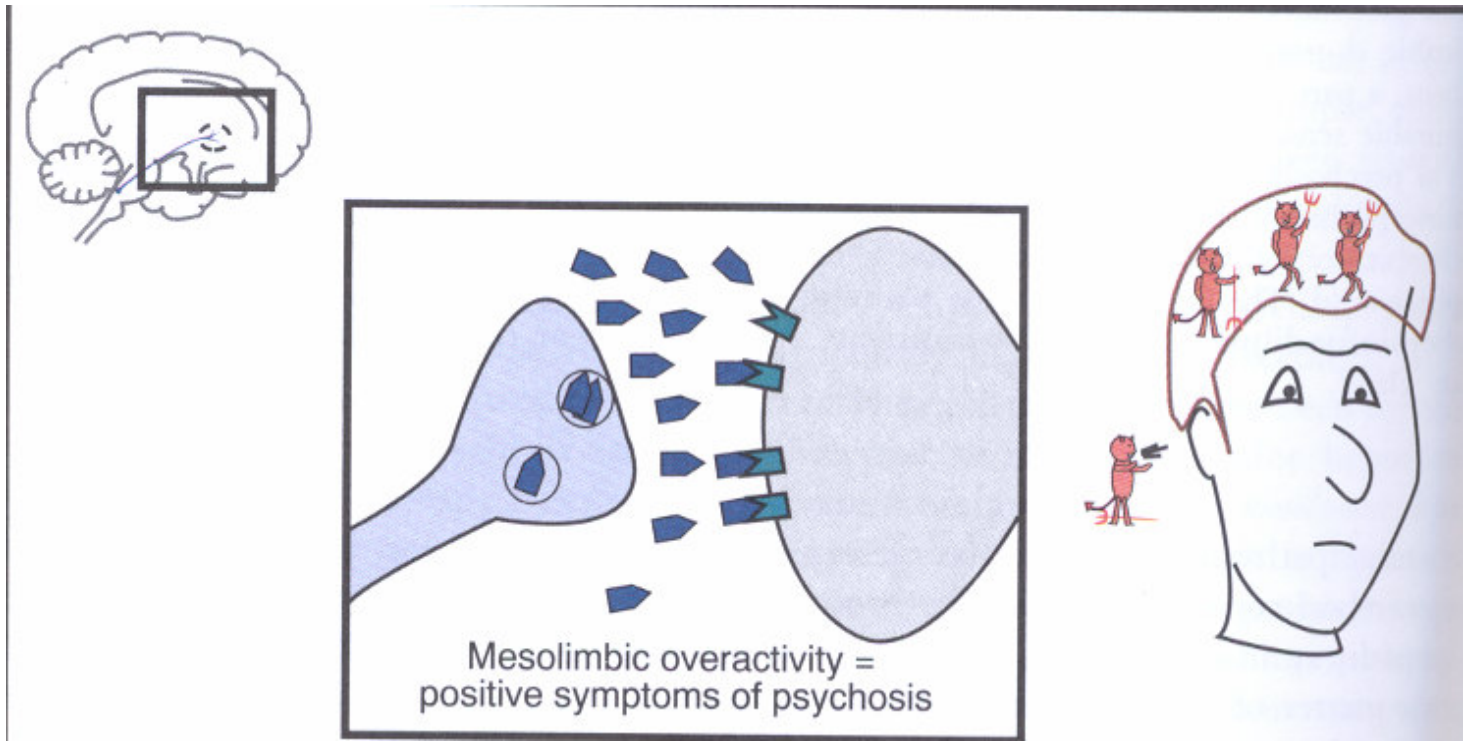
The Four Dopaminergic Pathways

Chemical pathways in the brain associated with feelings of pleasure

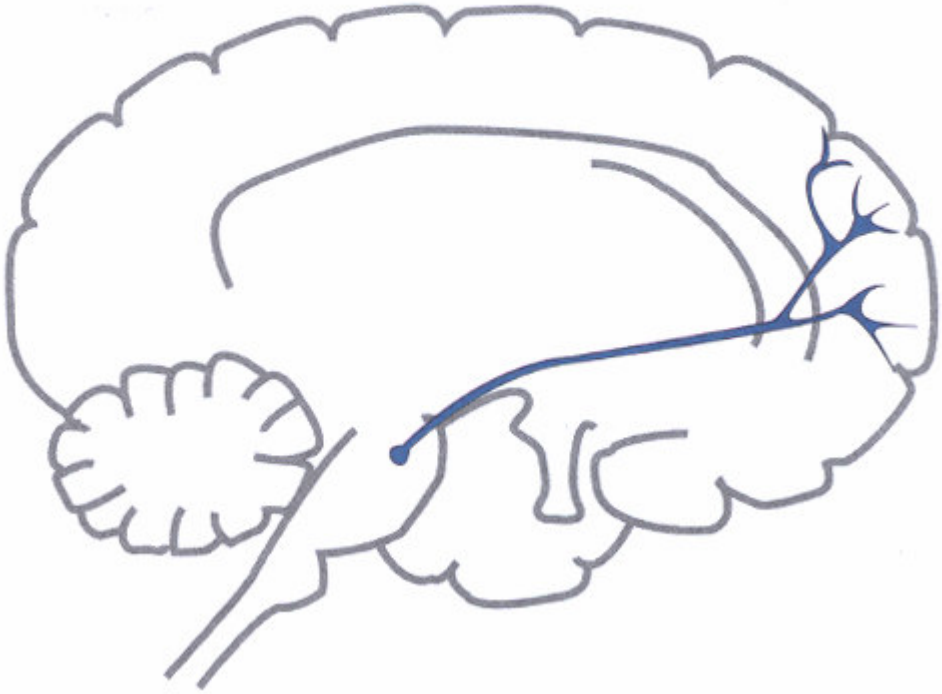

Dopamine Pathways
Basal ganglia
Nucleus accumbens
Substantia nigra
a
b
c
d
Hypothalamus
Tegmentum

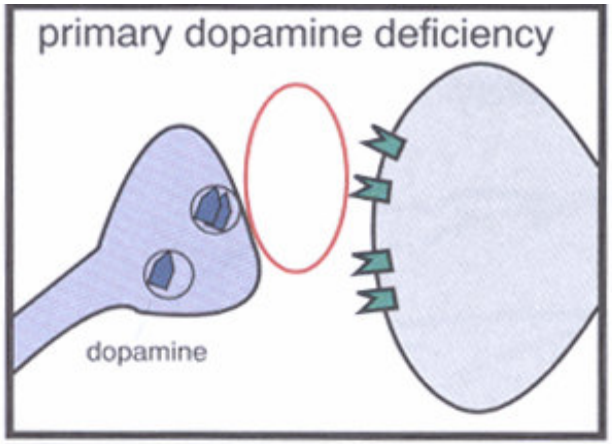
mesolimbic
pathway

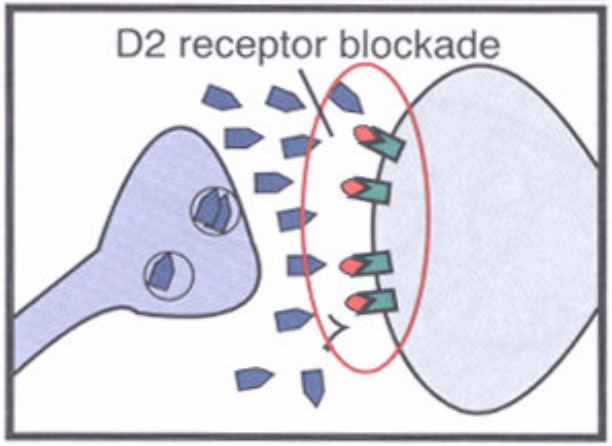


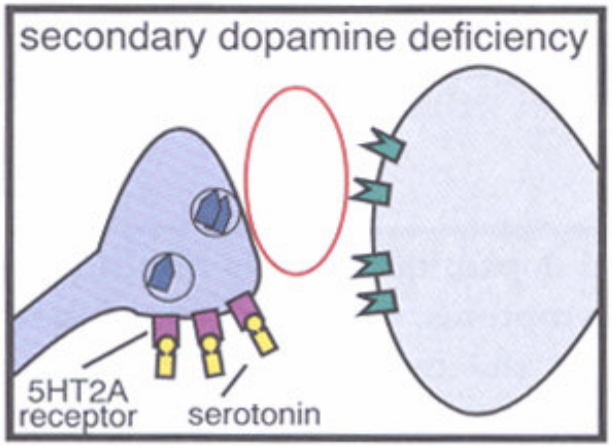

Mesolimbic overactivity =
positive symptoms of psychosis

meso-cortical
pathway







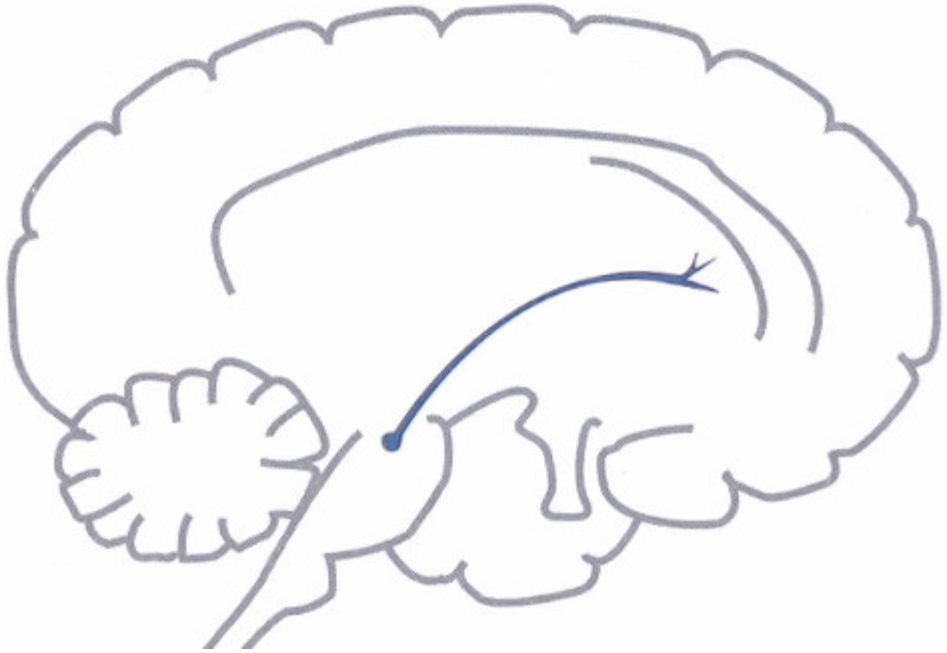


Mesocortical pathway

=

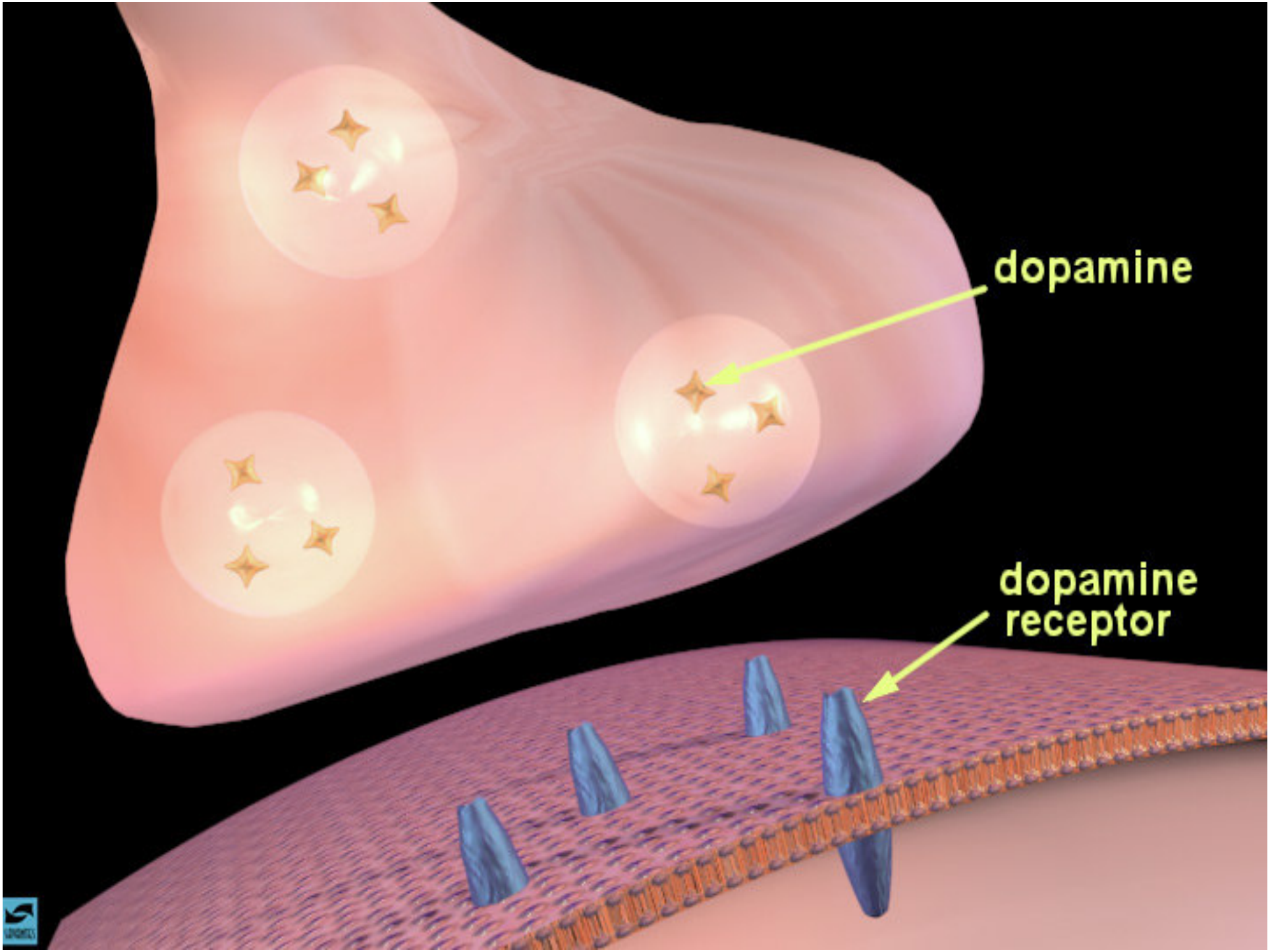
Increase in negative symptoms

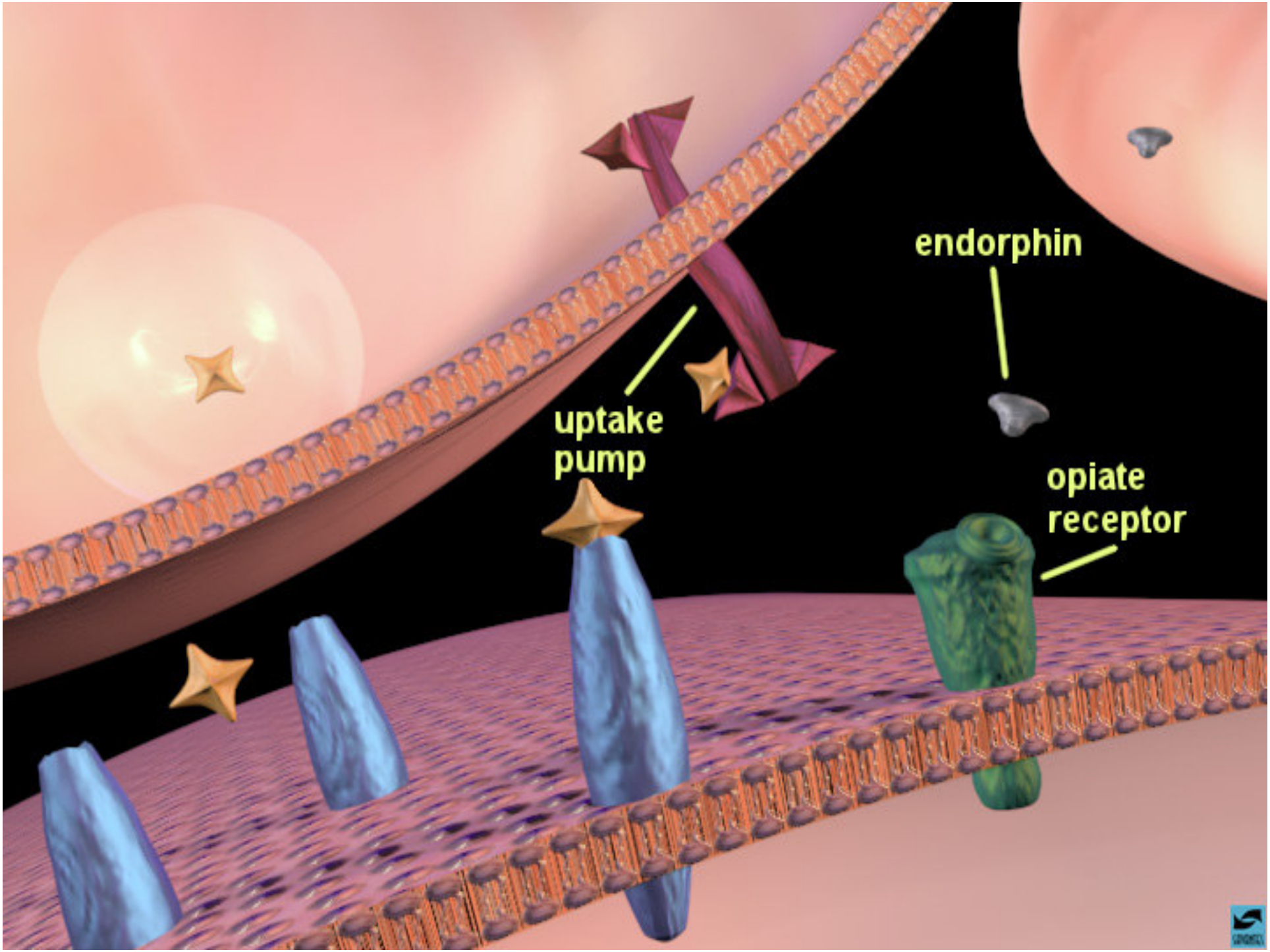
nigrostriatal
pathway

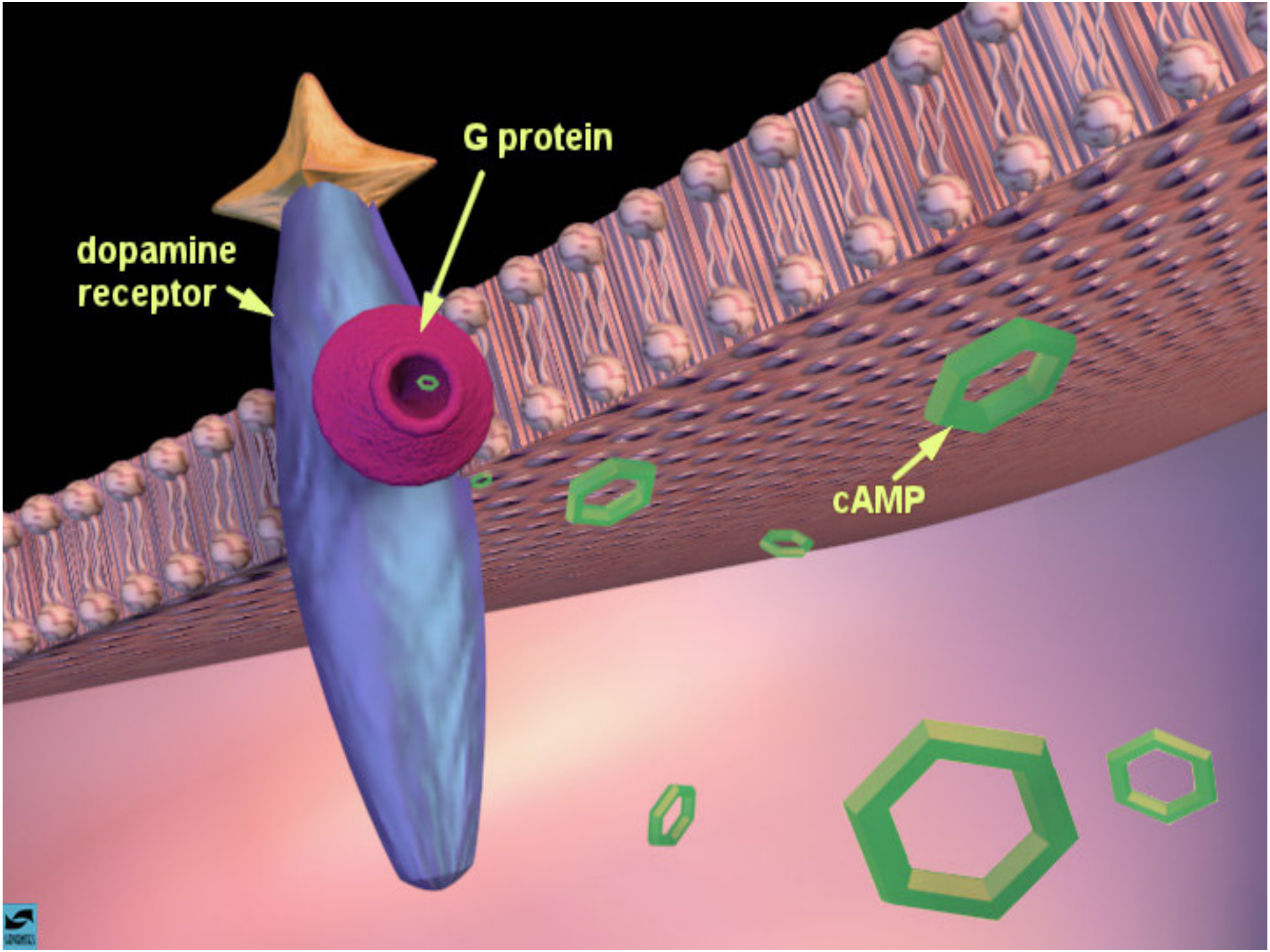


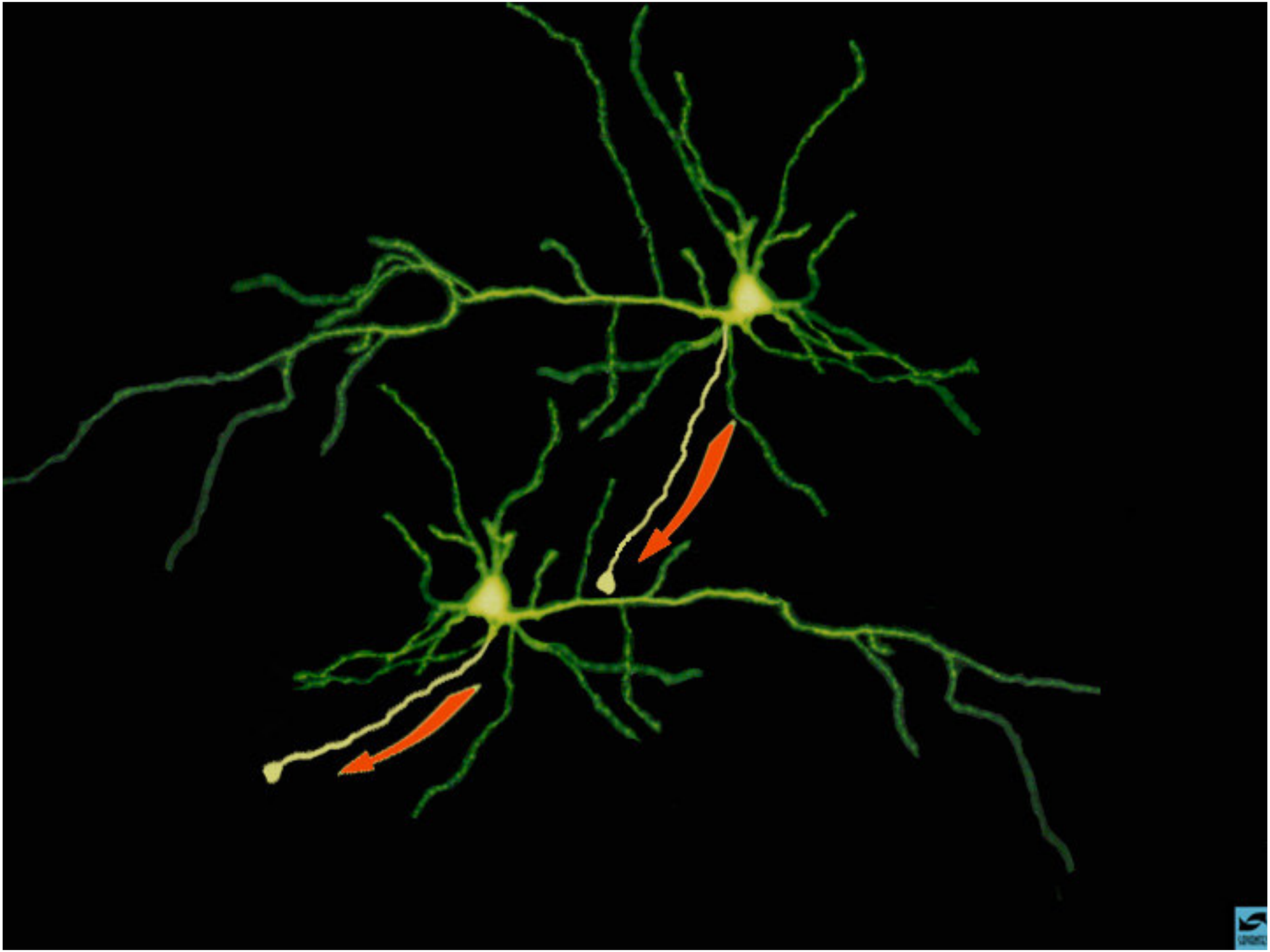
How Dopamine Works

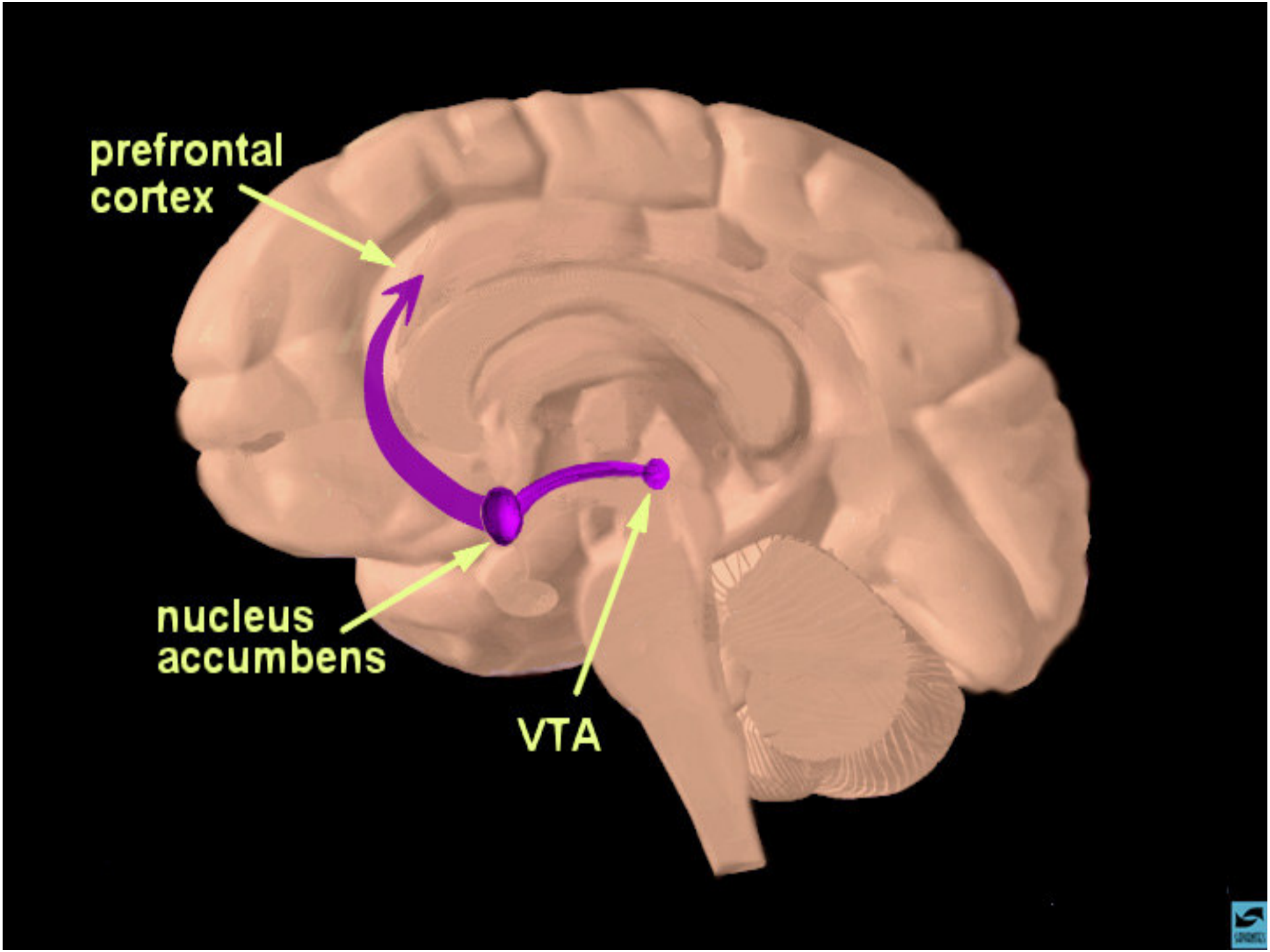
- The process of addiction disrupts the release of dopamine;
- This disruption changes the pleasure chemistry of the brain both functionally and structurally (genetically);
- Mental illness is the result of these changes.

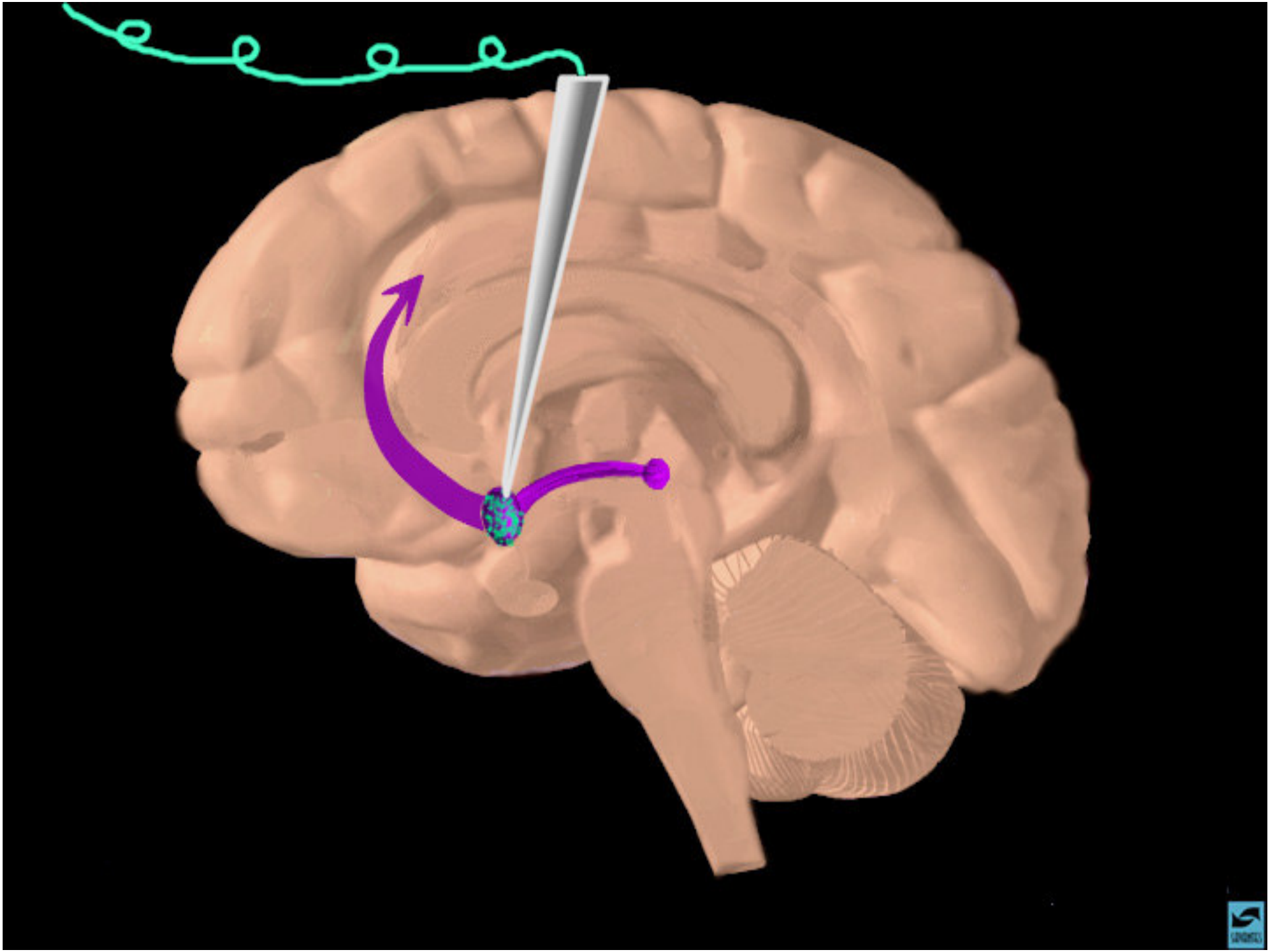

dopamine
dopamine receptor

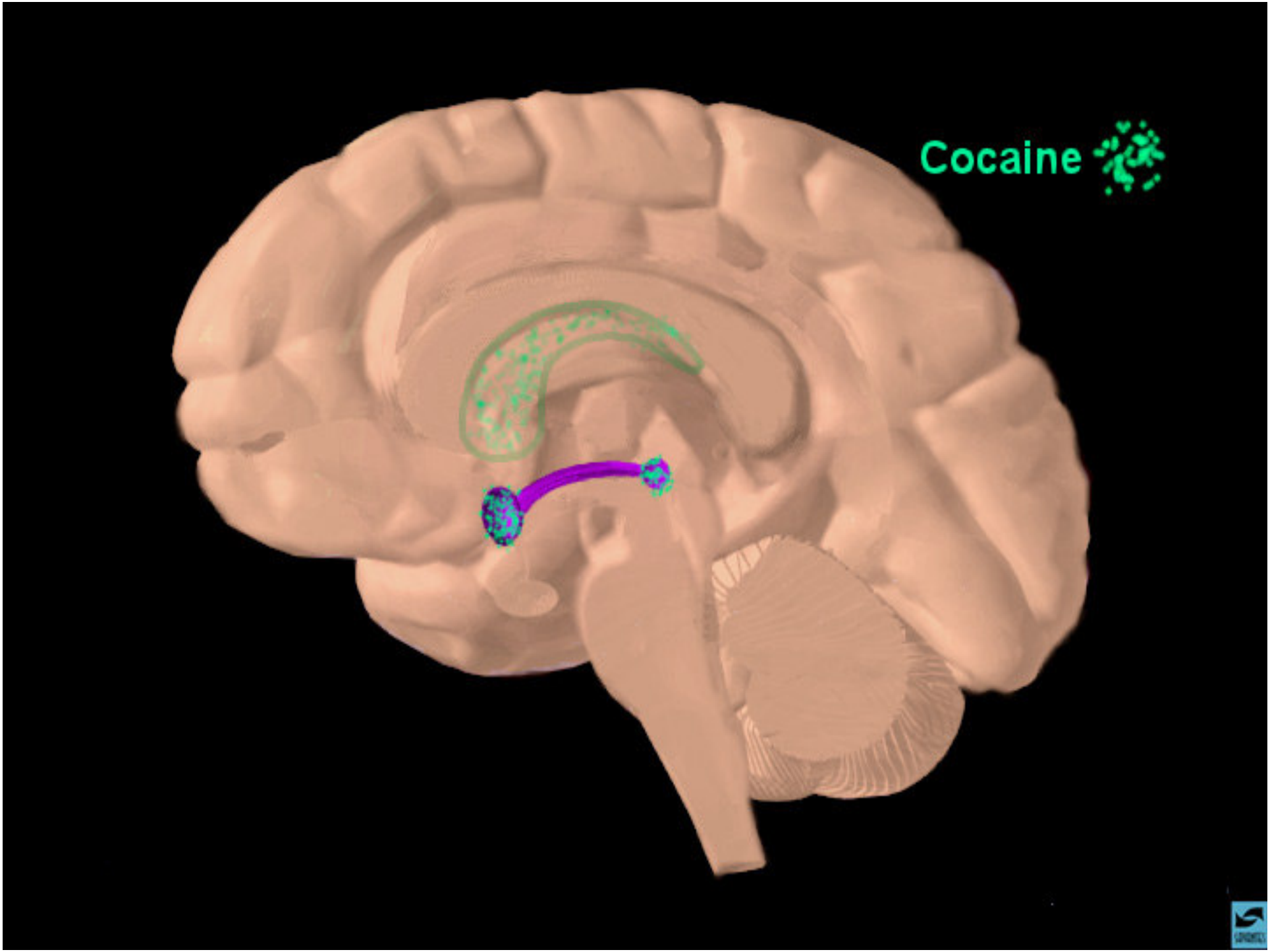

endorphin
uptake
pump
opiate
receptor

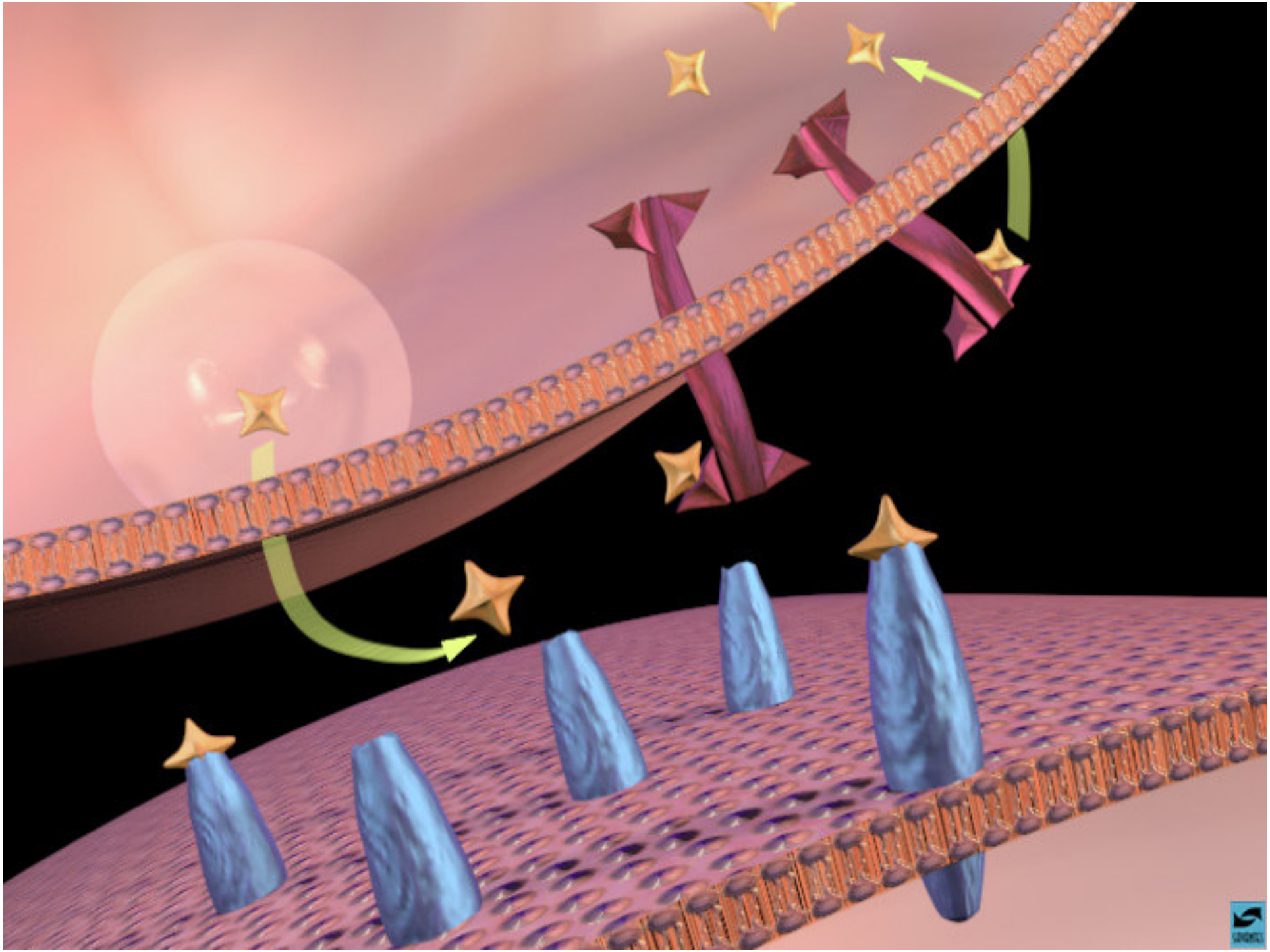

G protein
dopamine
receptor
cAMP

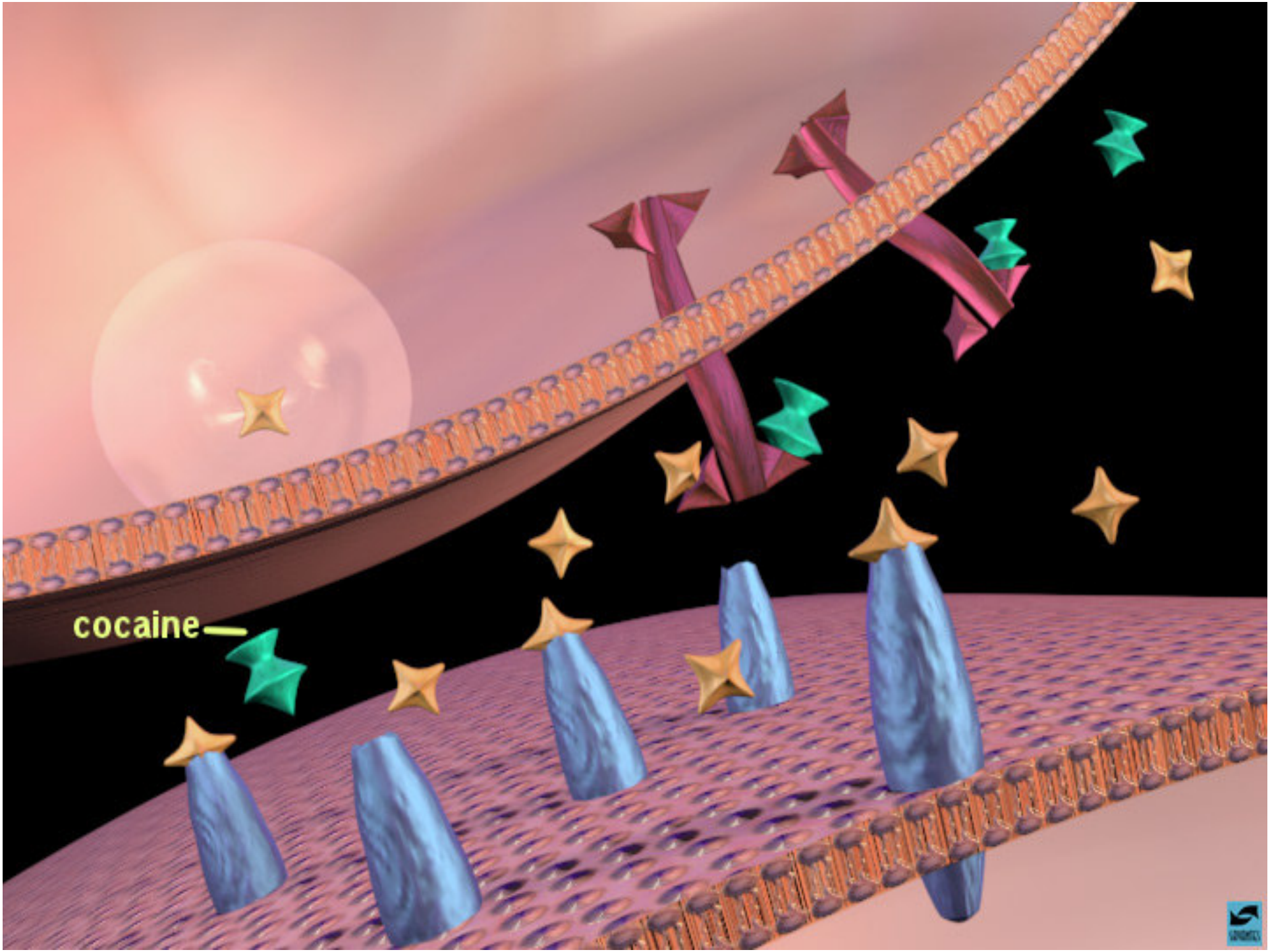


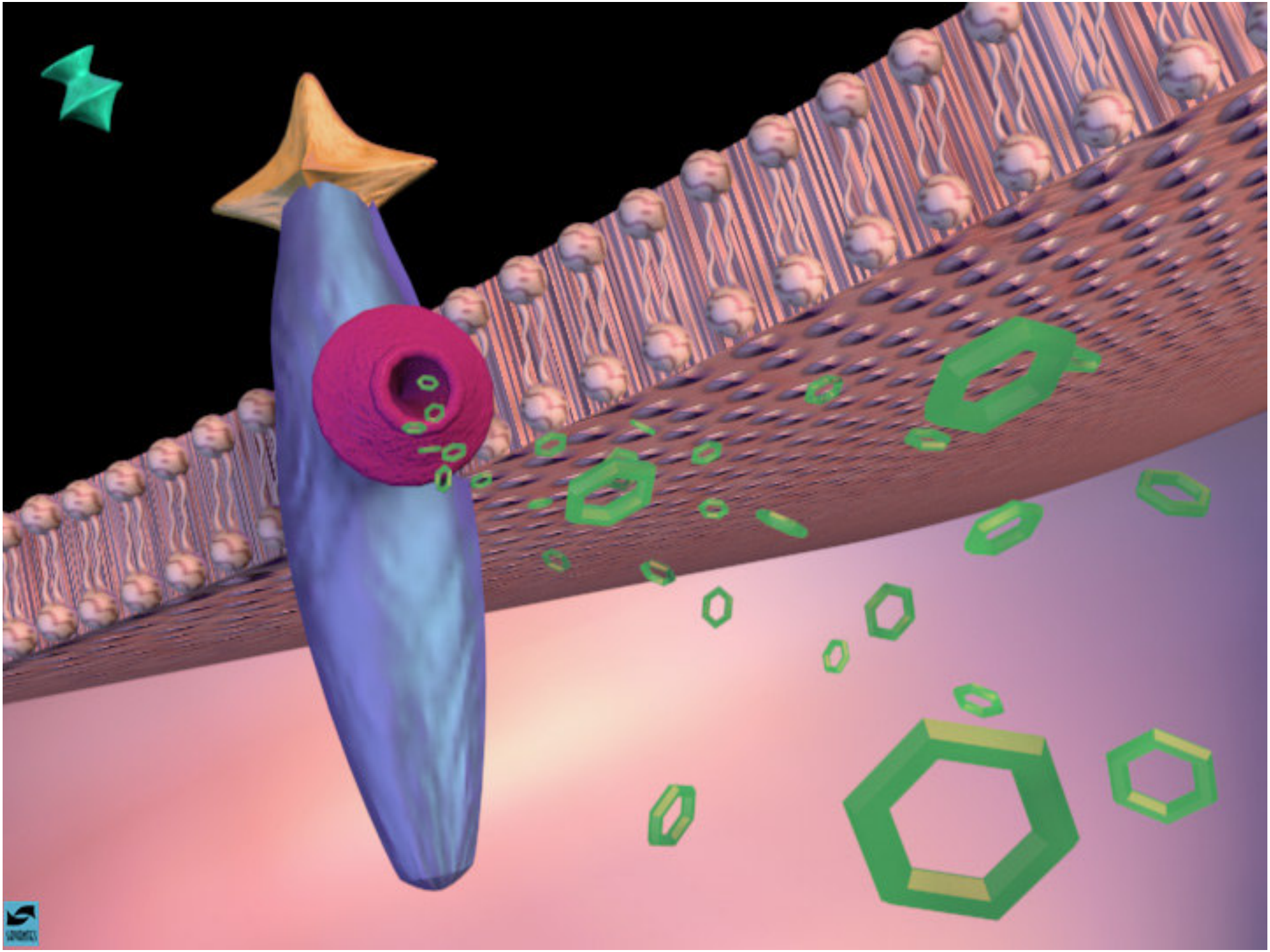

prefrontal
cortex
nucleus
accumbens
VTA

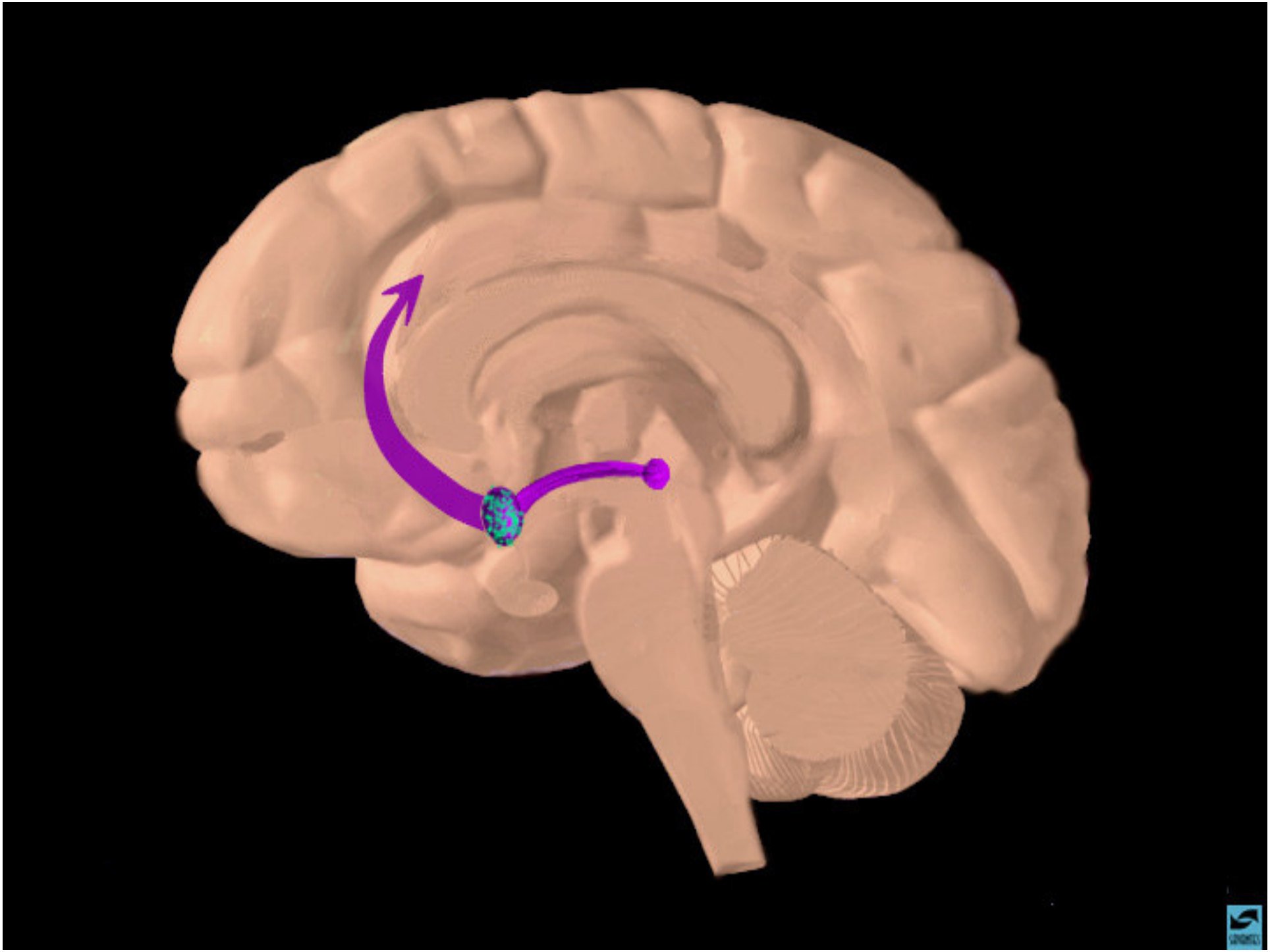


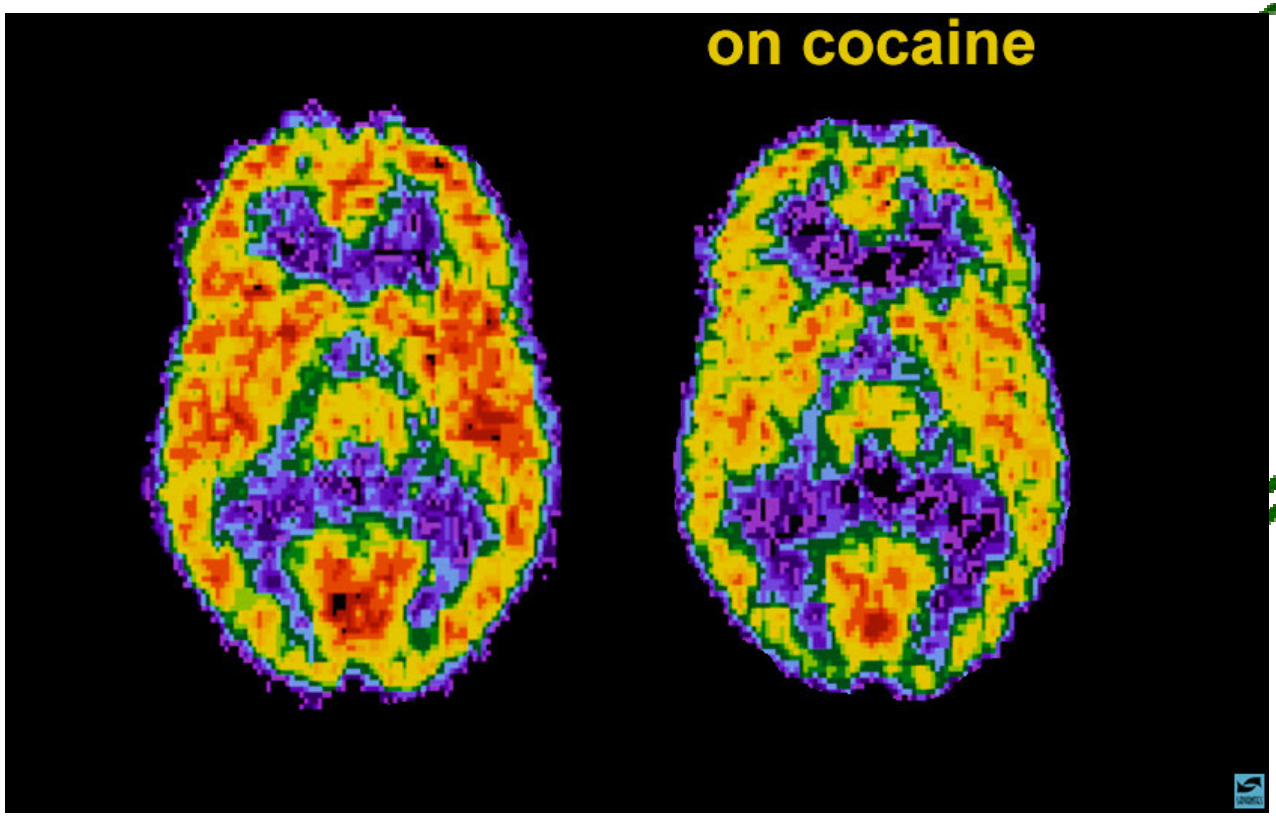

Cocaine

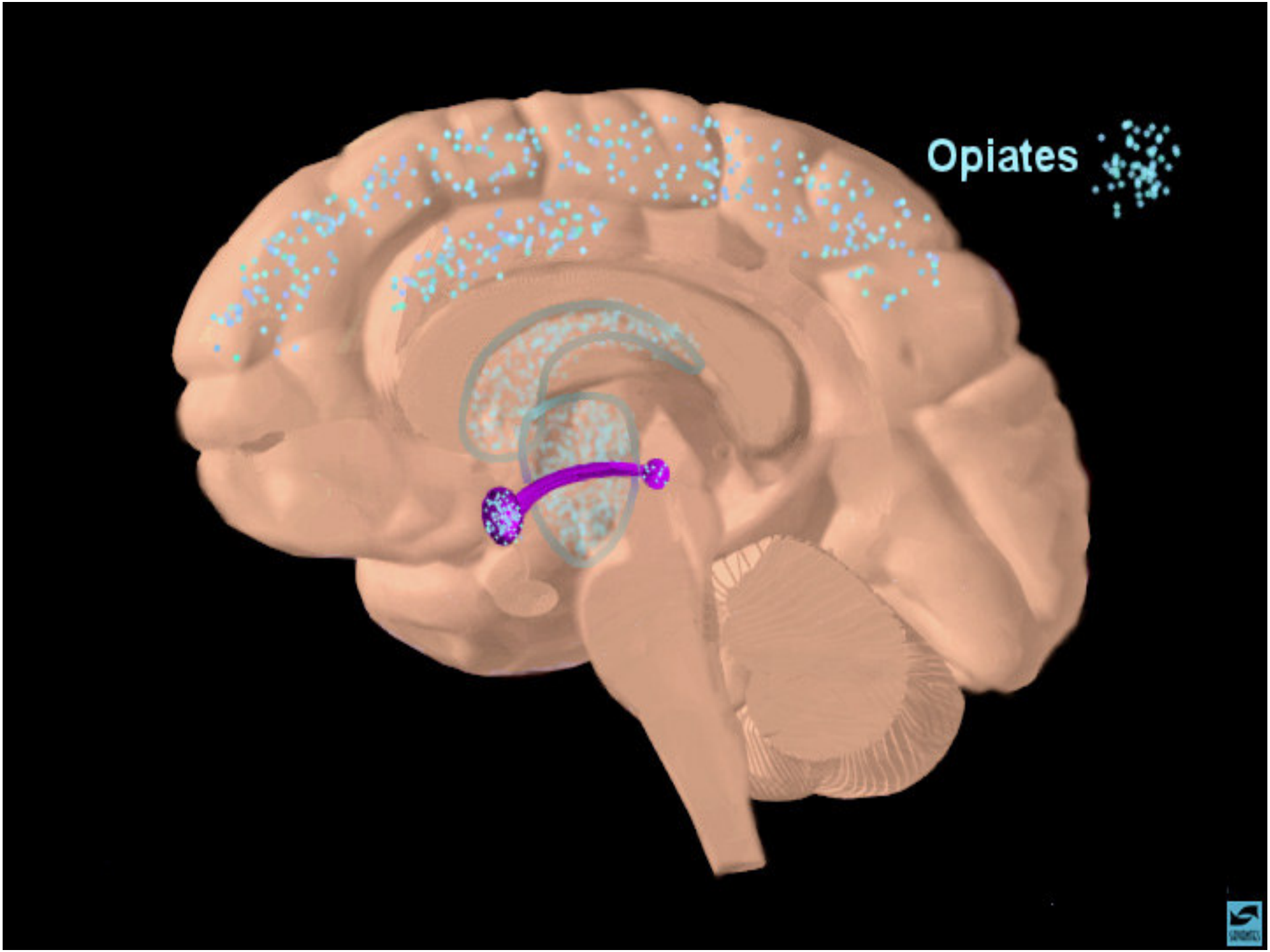


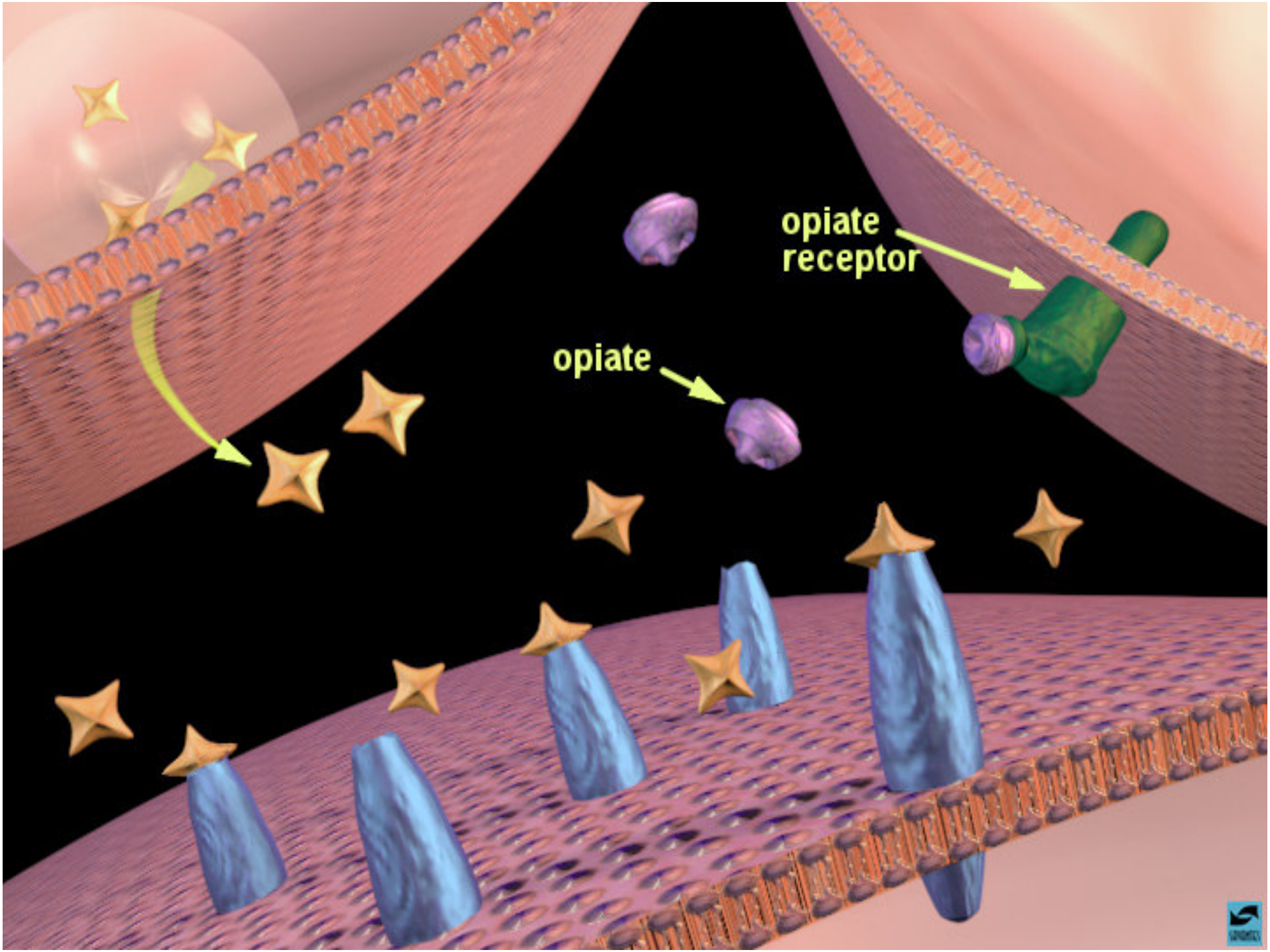

cocaine

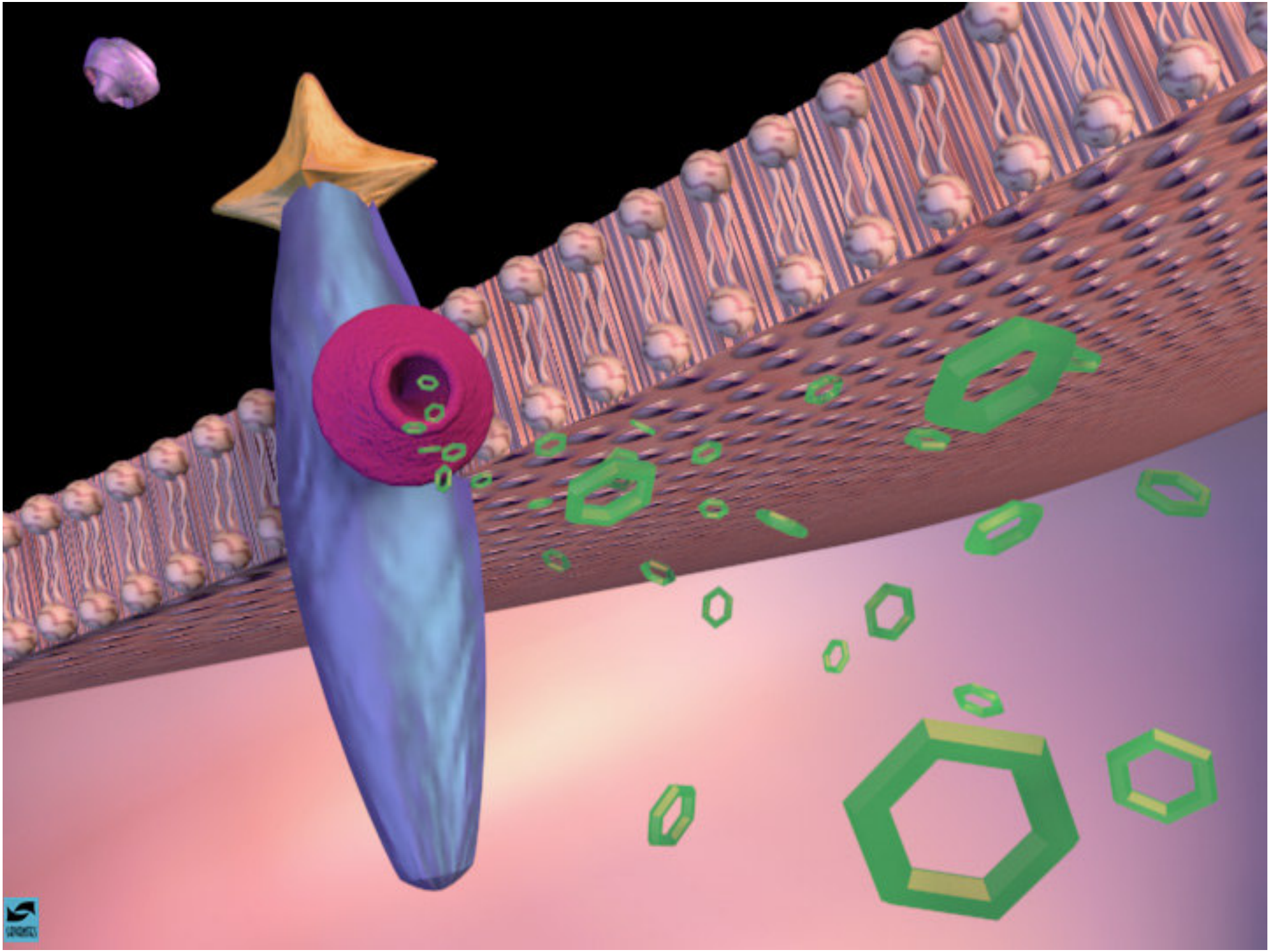


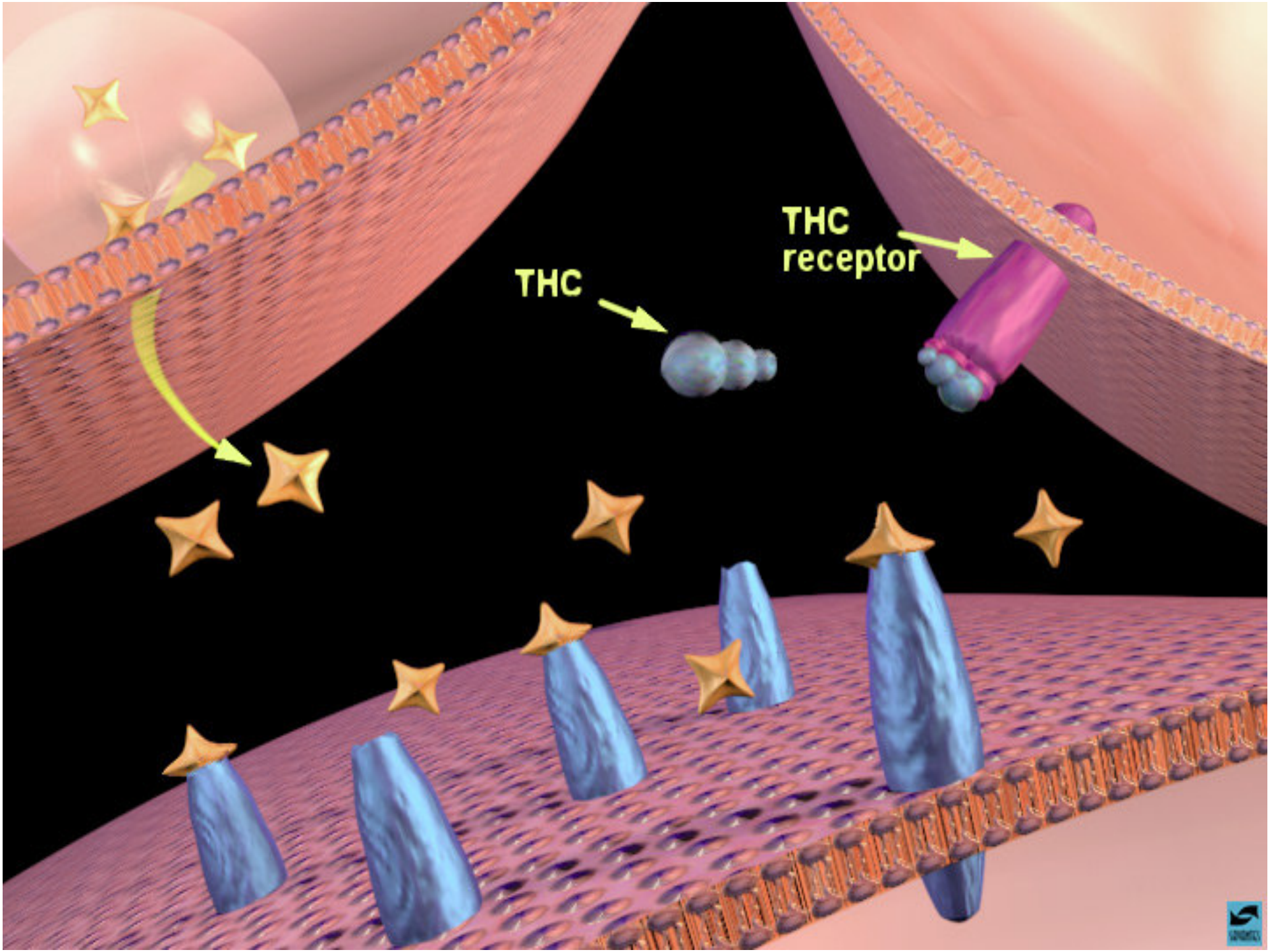


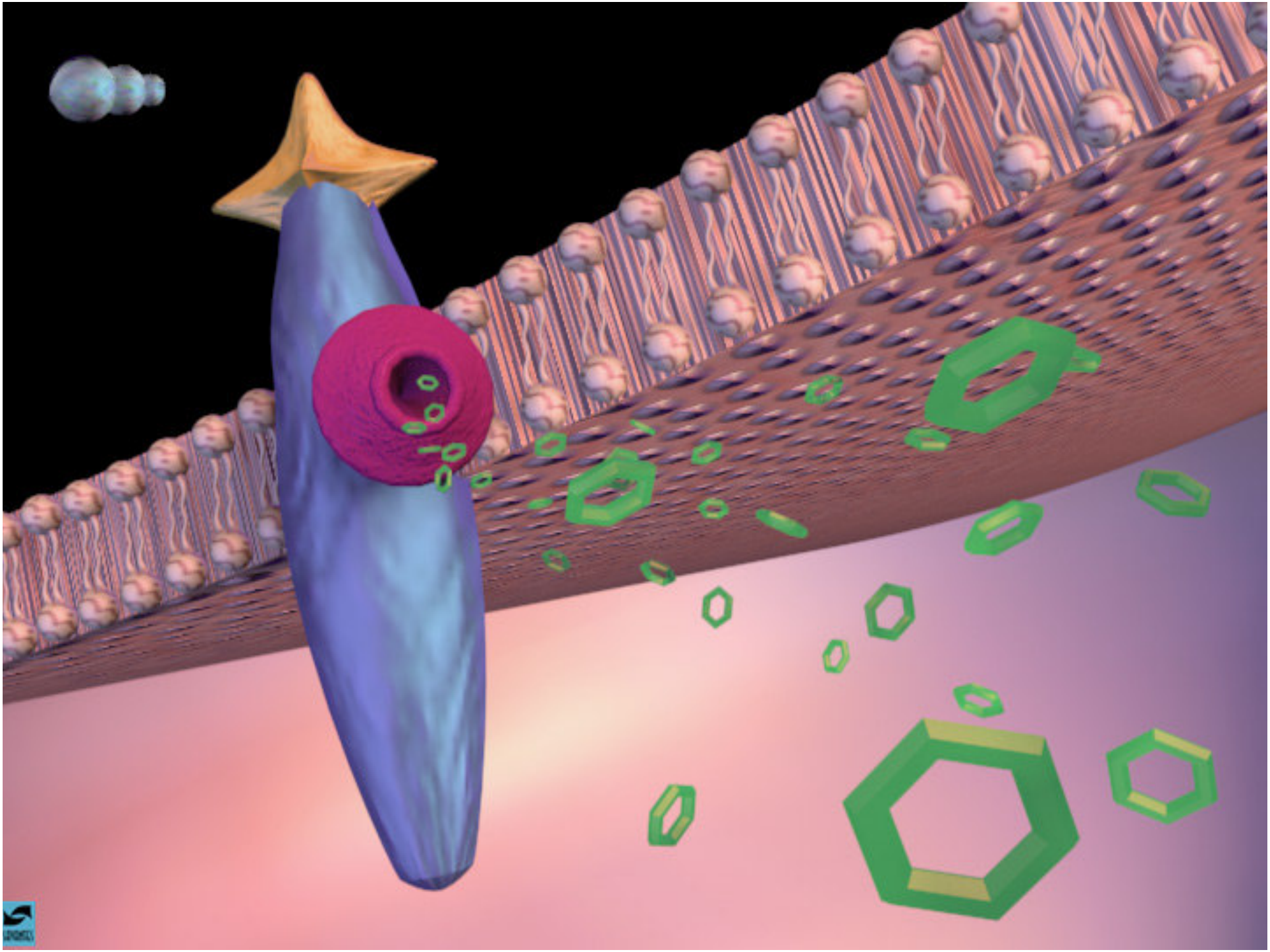

on cocaine


Opiates


opiate
receptor
opiate



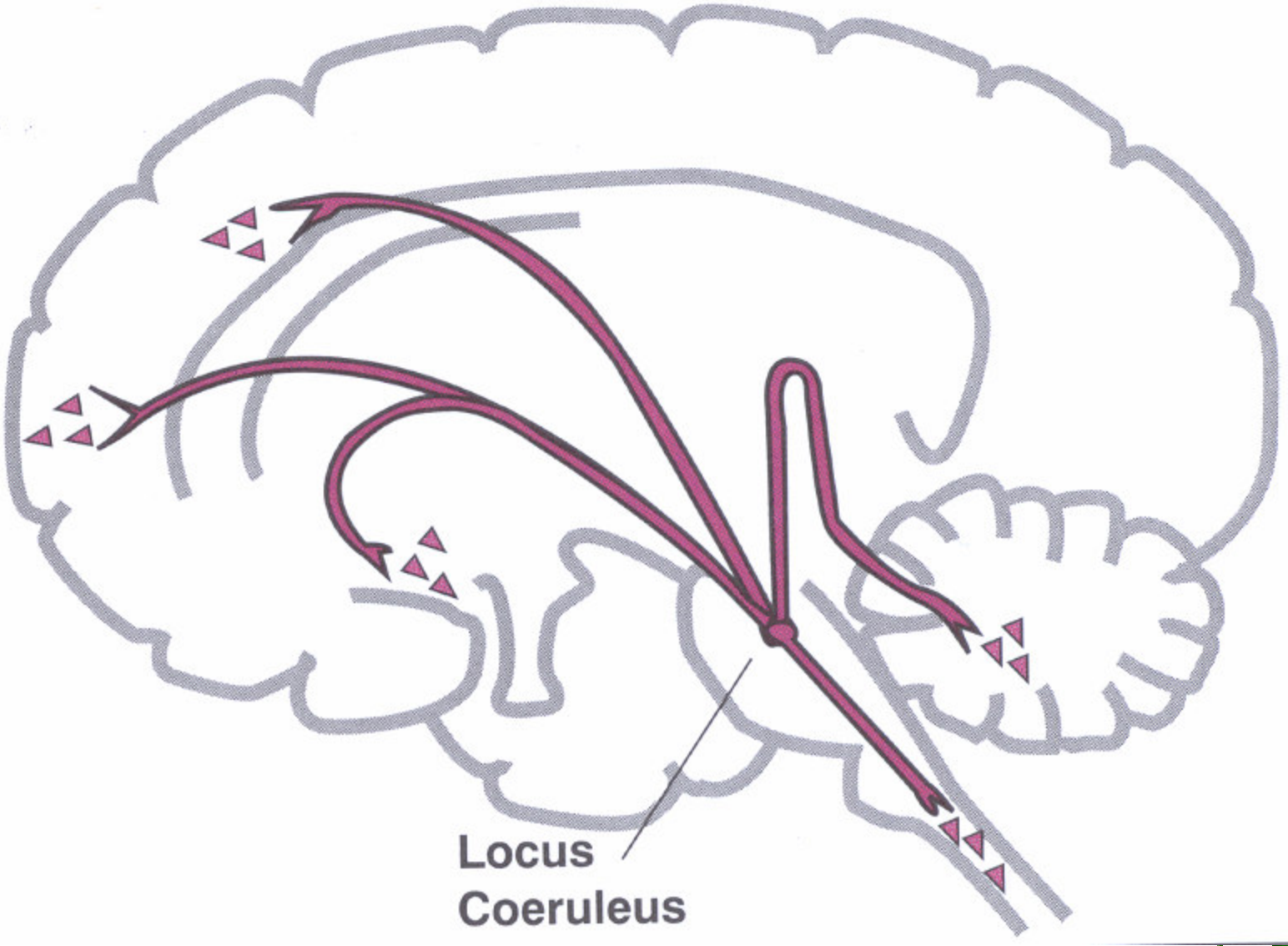

THC
THC receptor



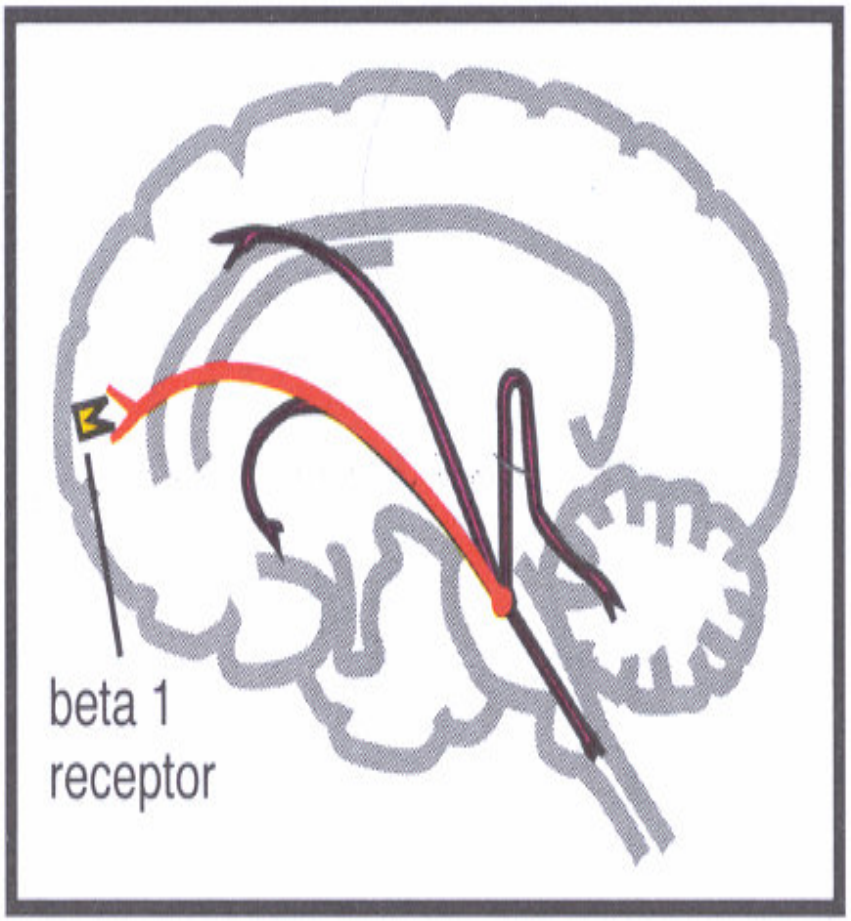
The Norepinephreine Pathways

- Norepinephrine is related to the following physiological/psychological states:
  - Attention
  - Concentration
  - Working memory
  - Speed of information processing
  - Mood
  - Psychomotor activities
  - Mood

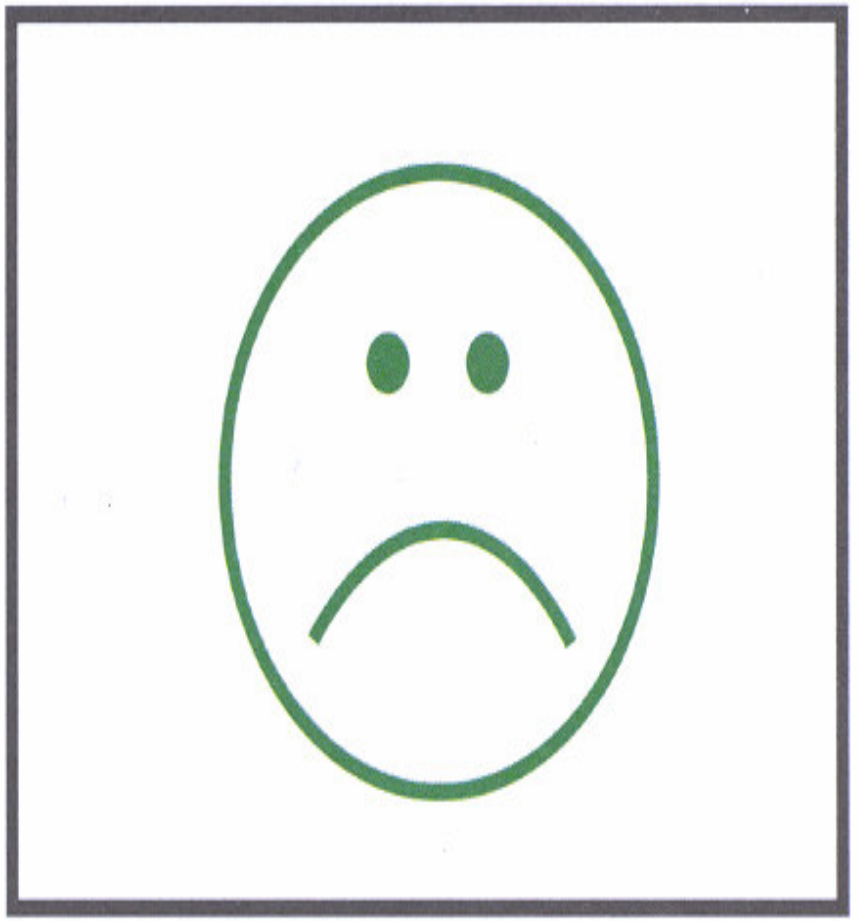
Norepinephrine Pathways

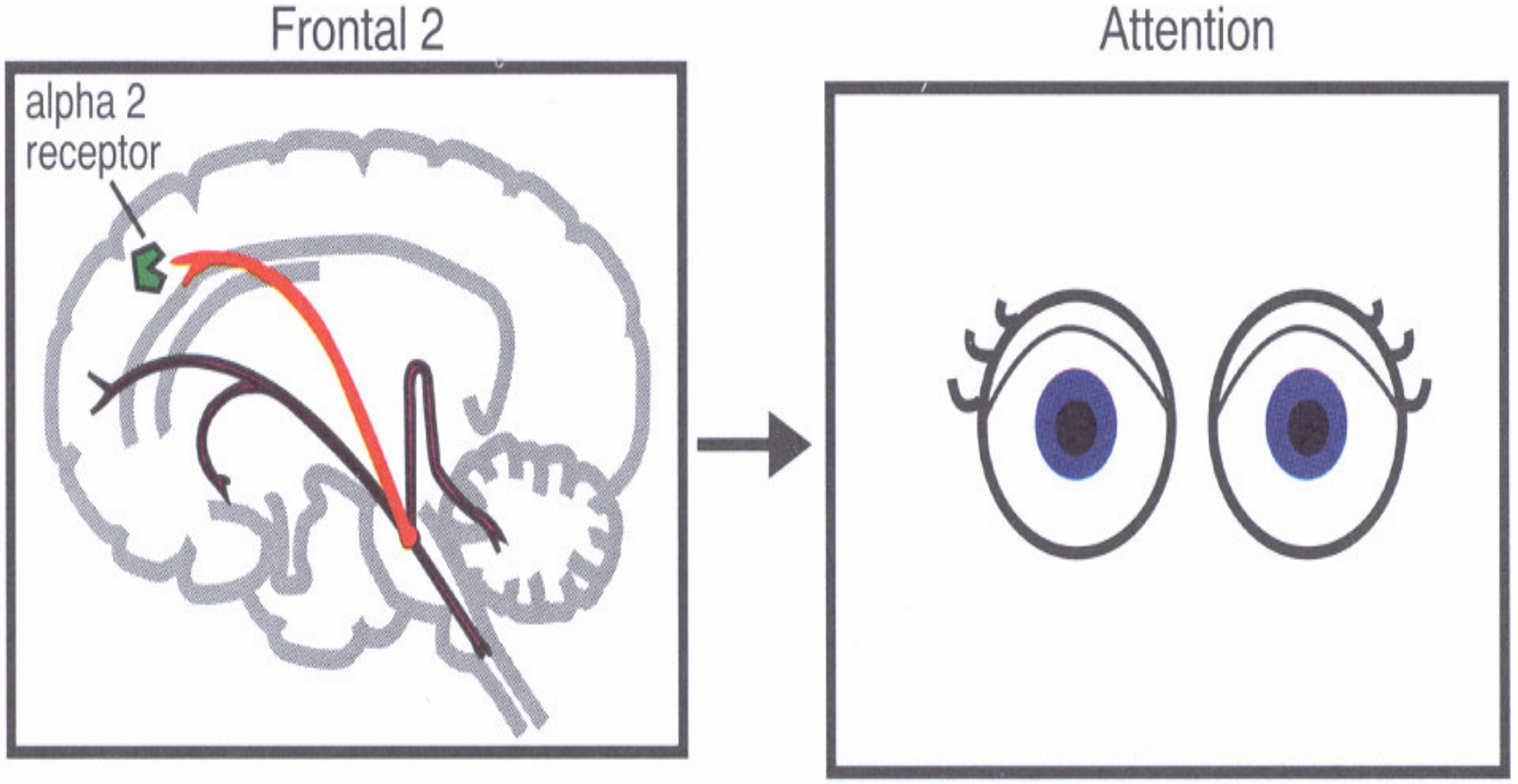


Frontal 1

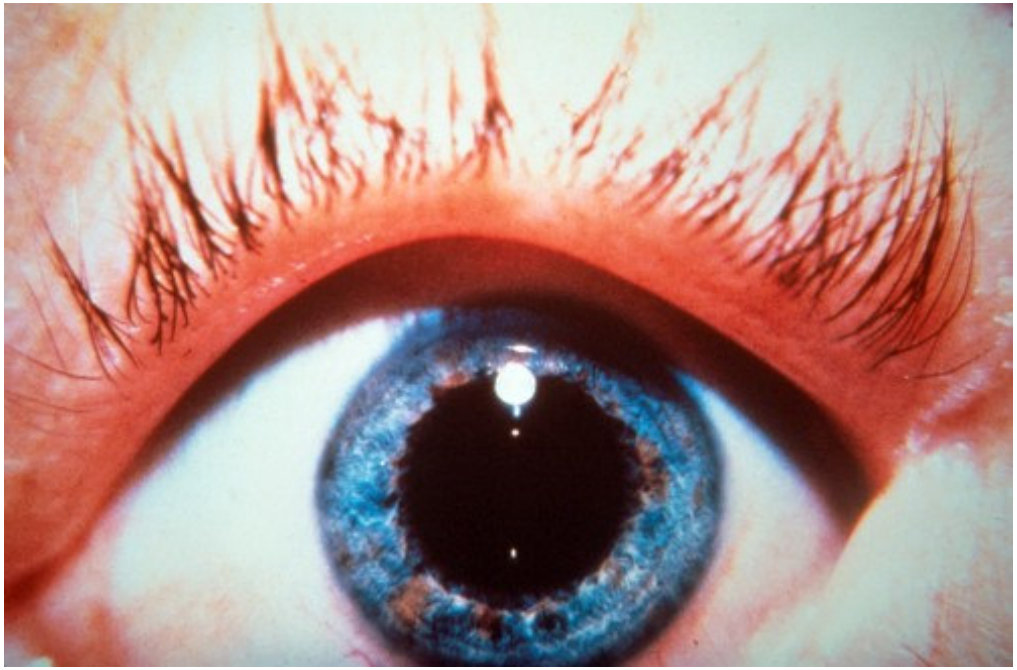


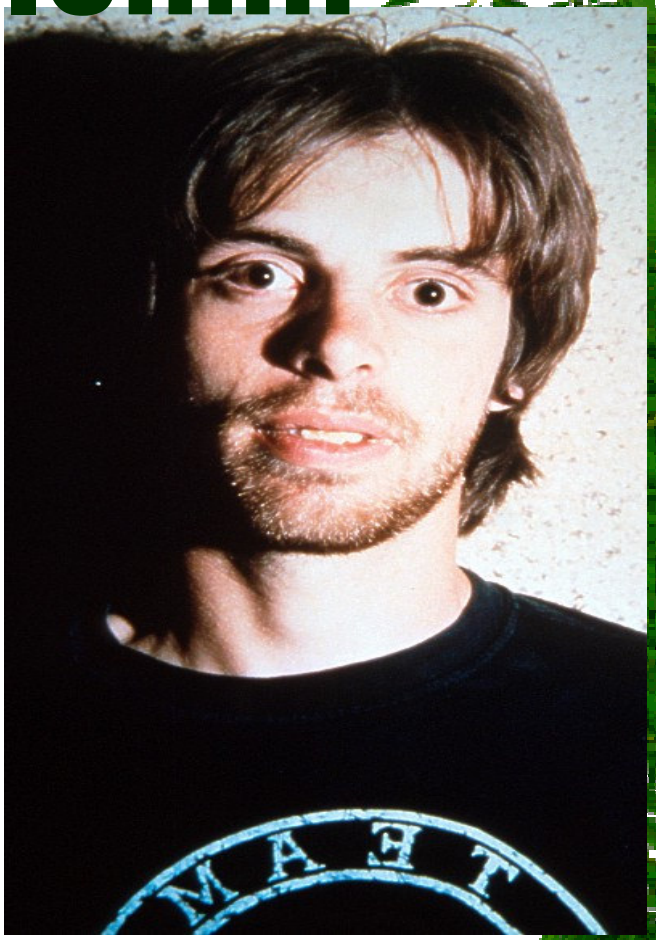
Depression



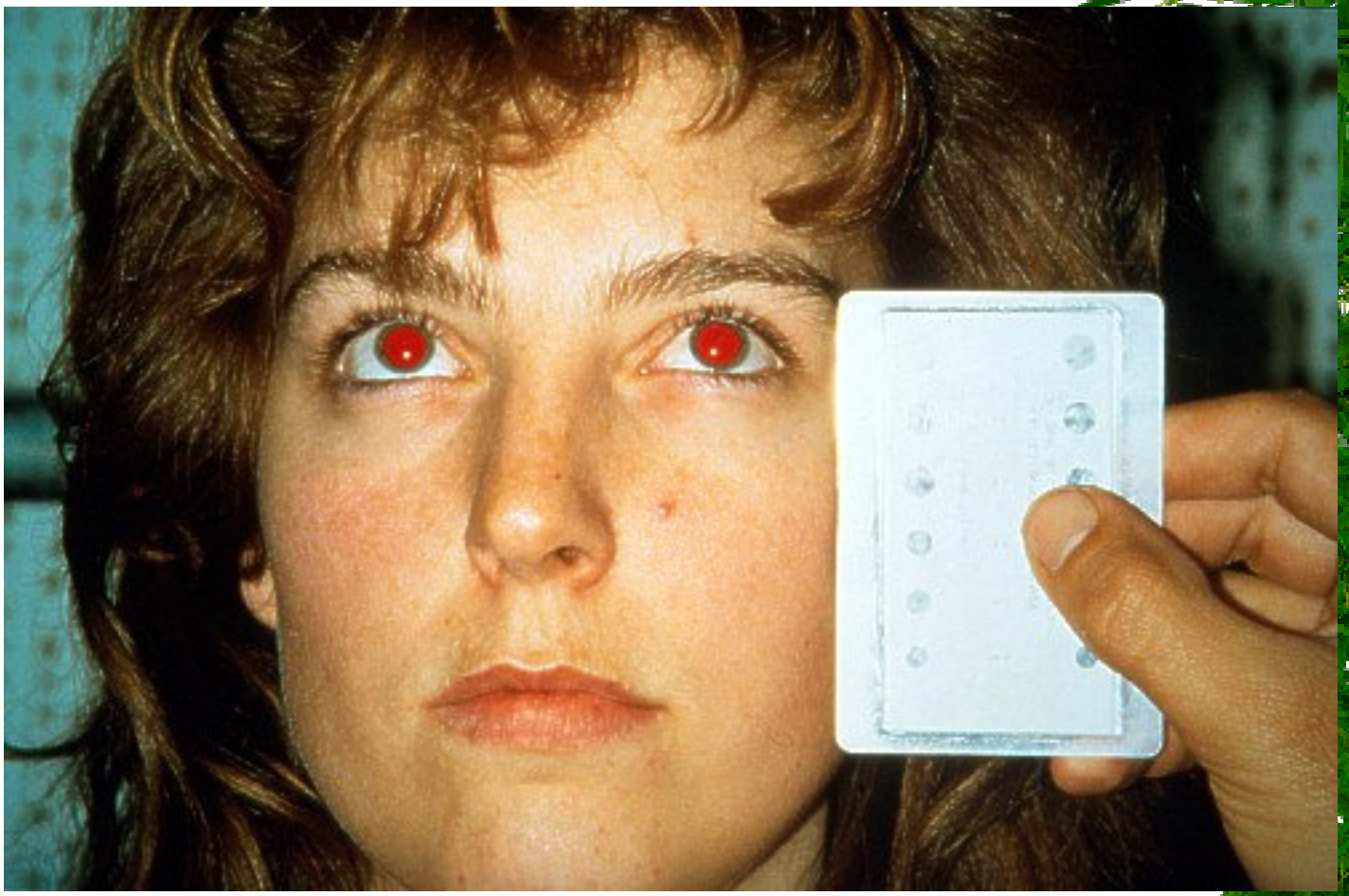

Frontal 2
alpha 2
receptor
Attention

Pupils 6.5mm to 7.0mm

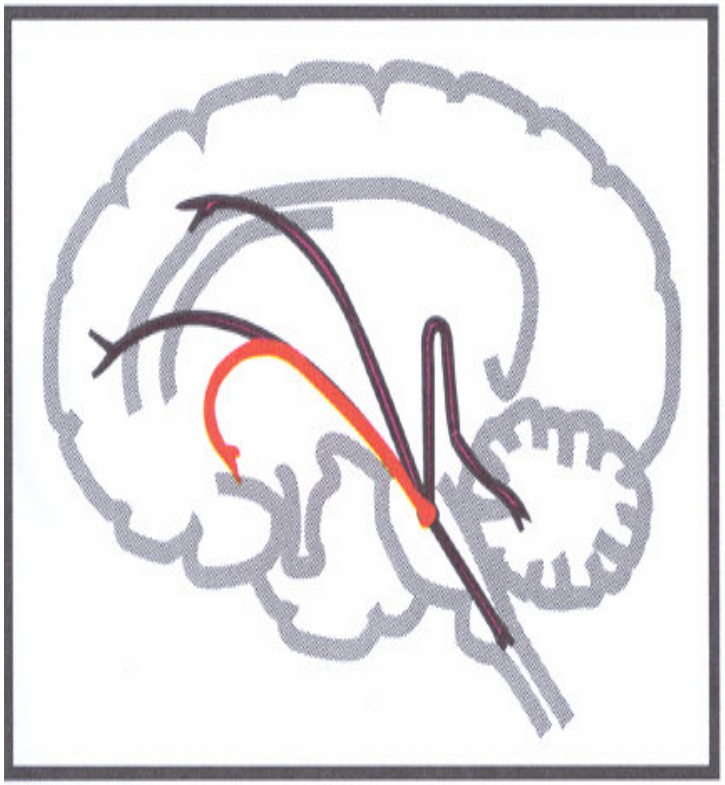


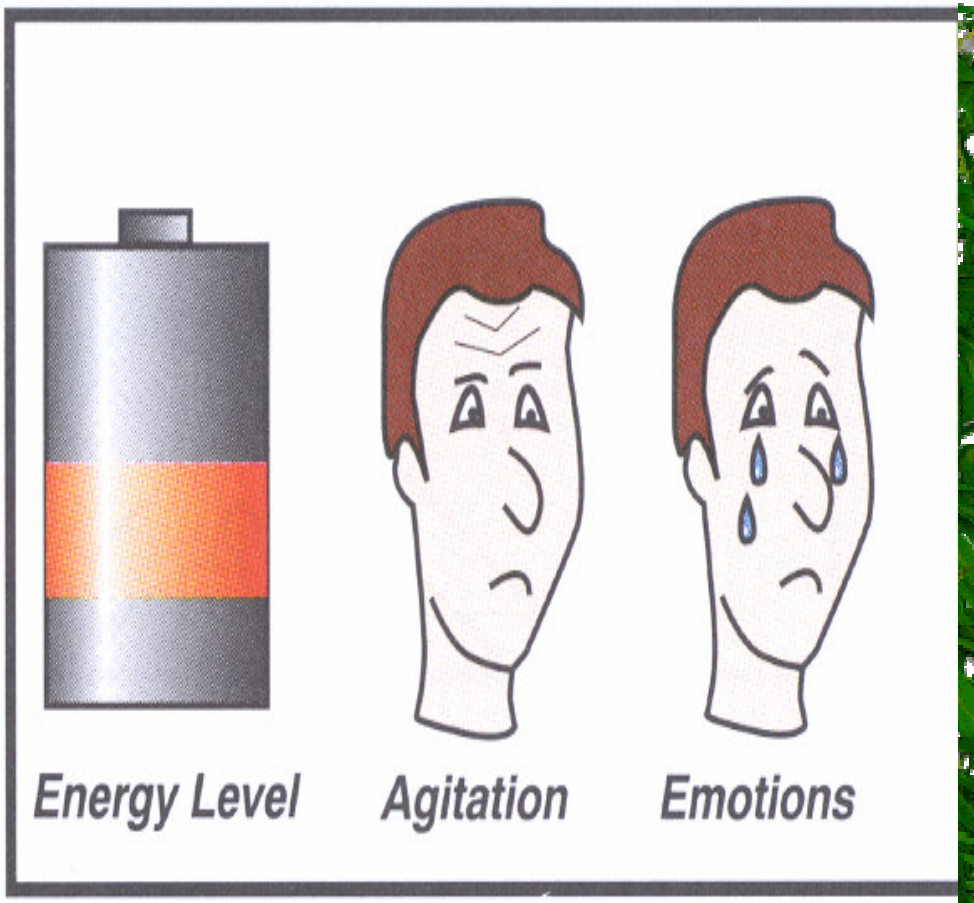


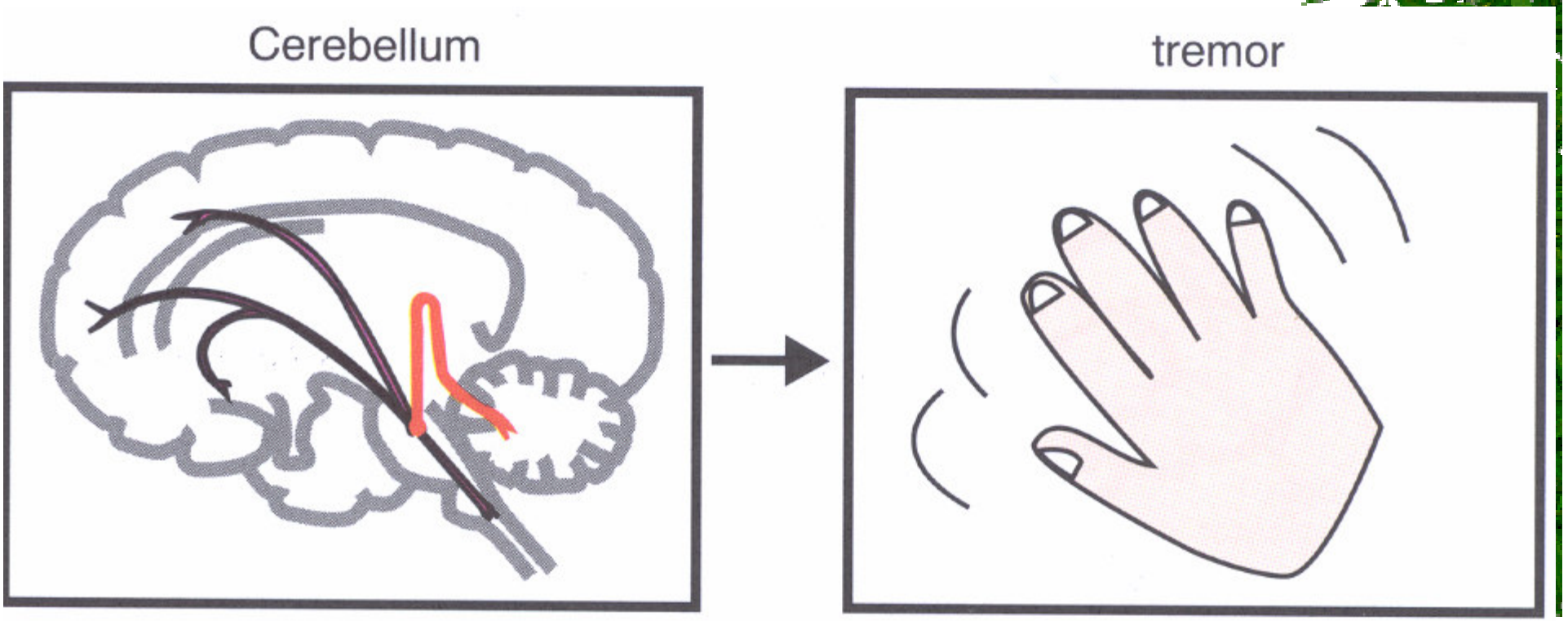
Pupils

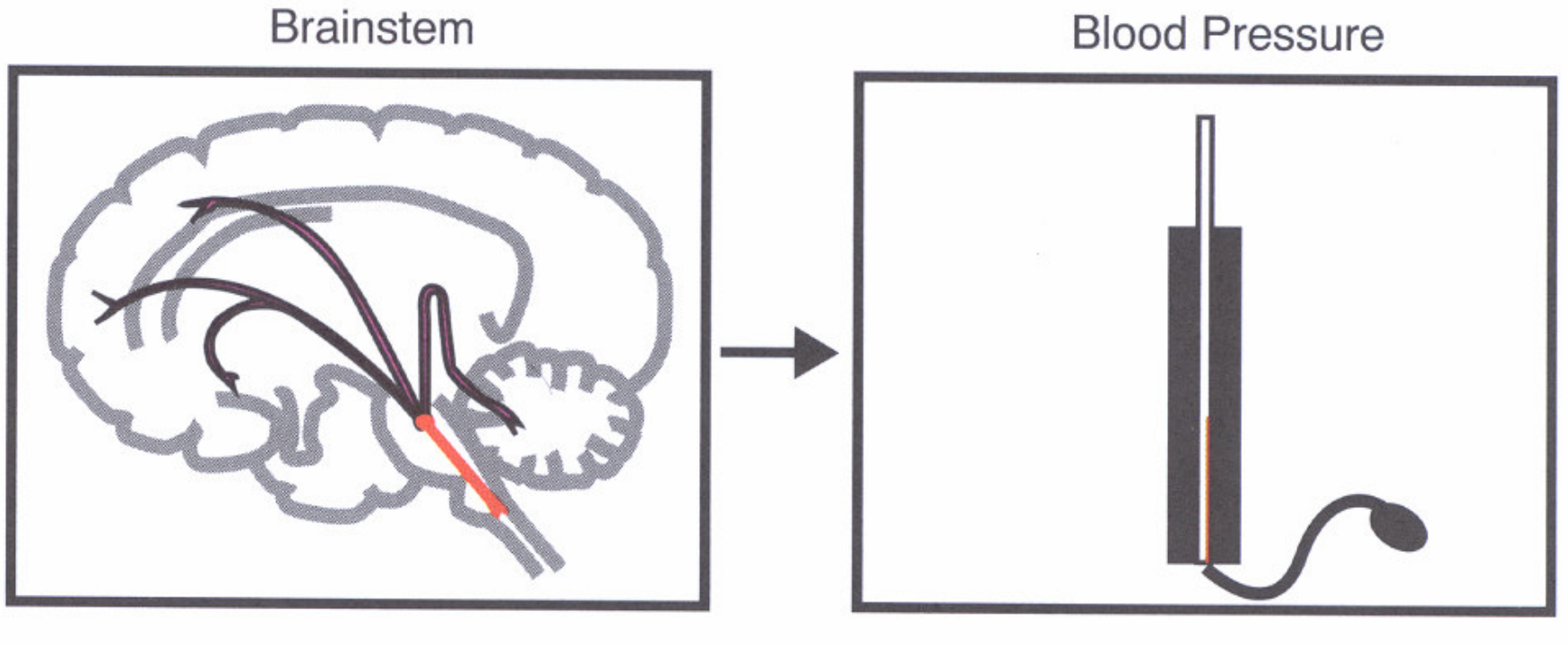


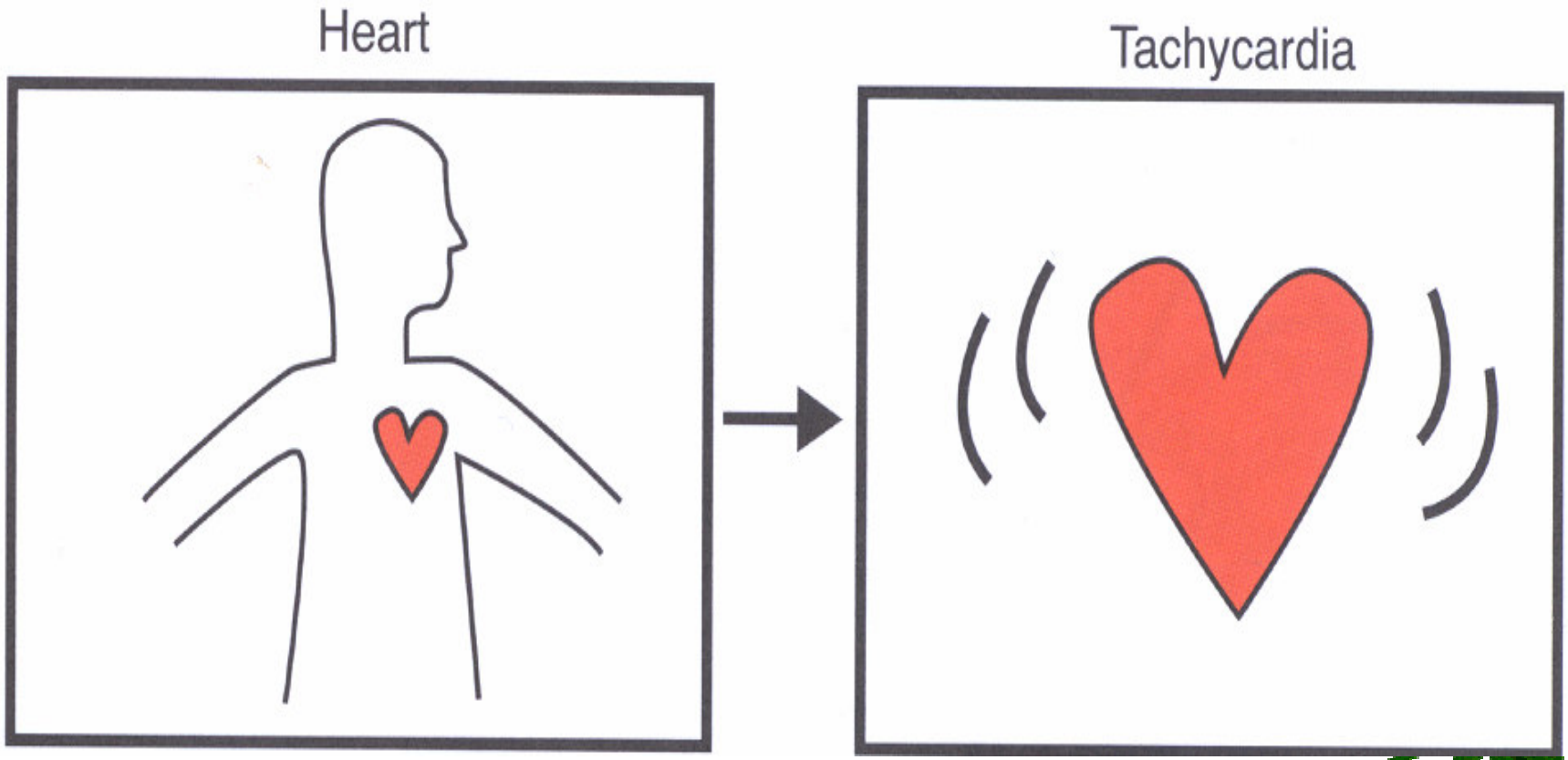
Limbic





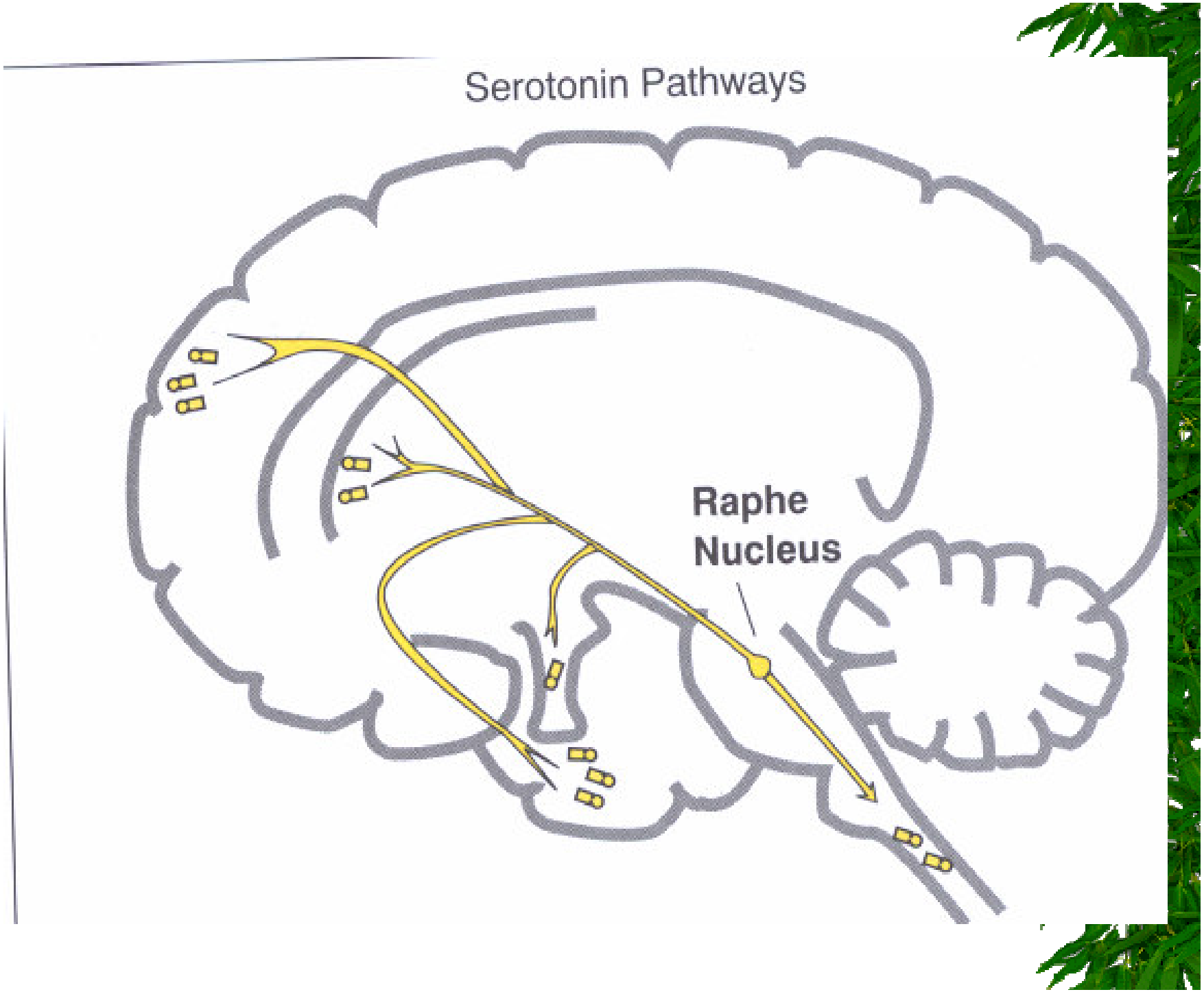

Cerebellum
tremor

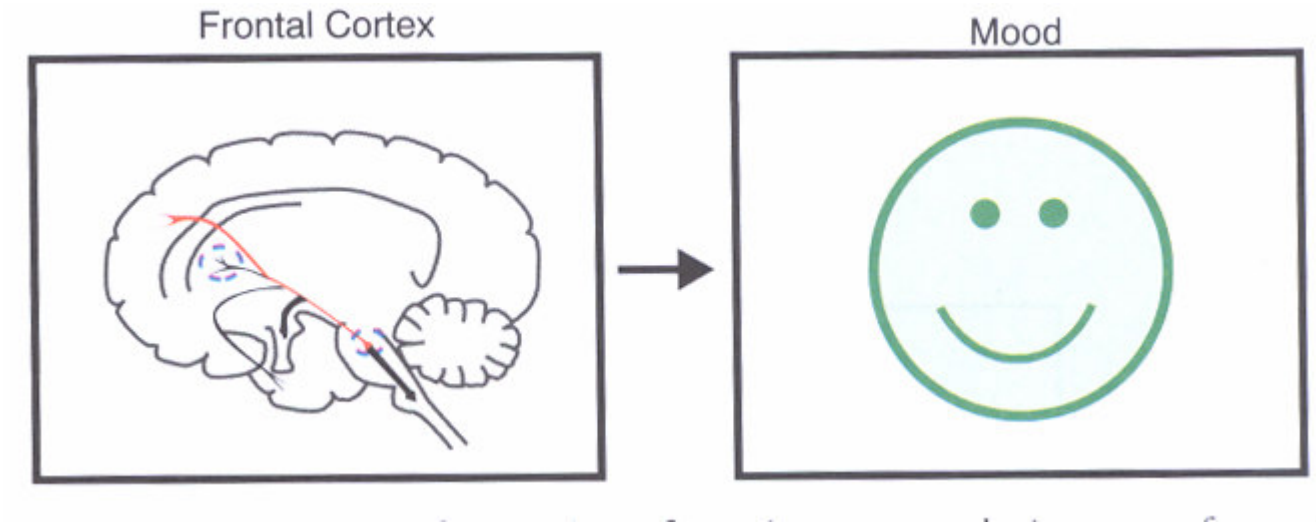

Brainstem
Blood Pressure

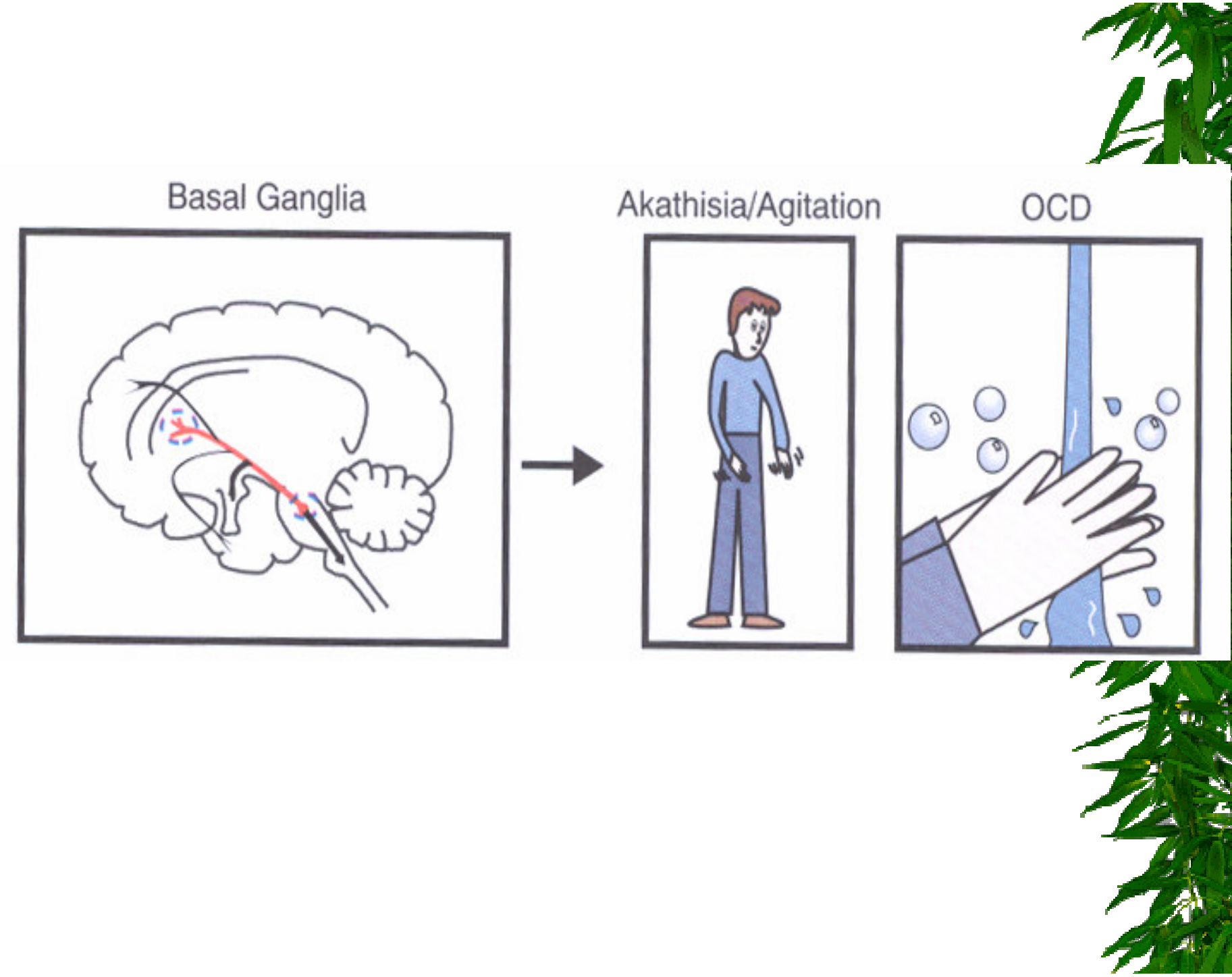

Heart
Tachycardia

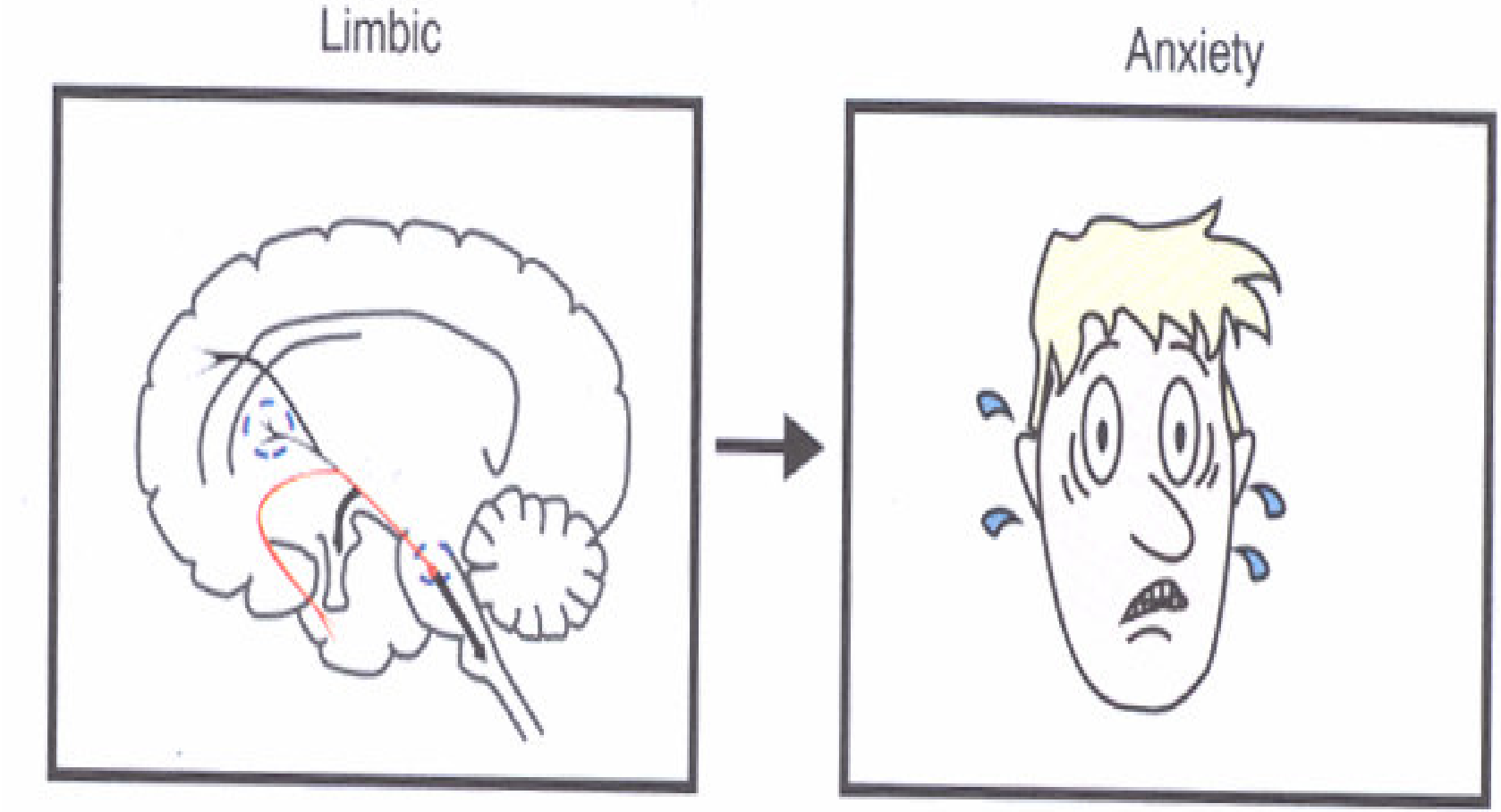
Serotonin Pathways

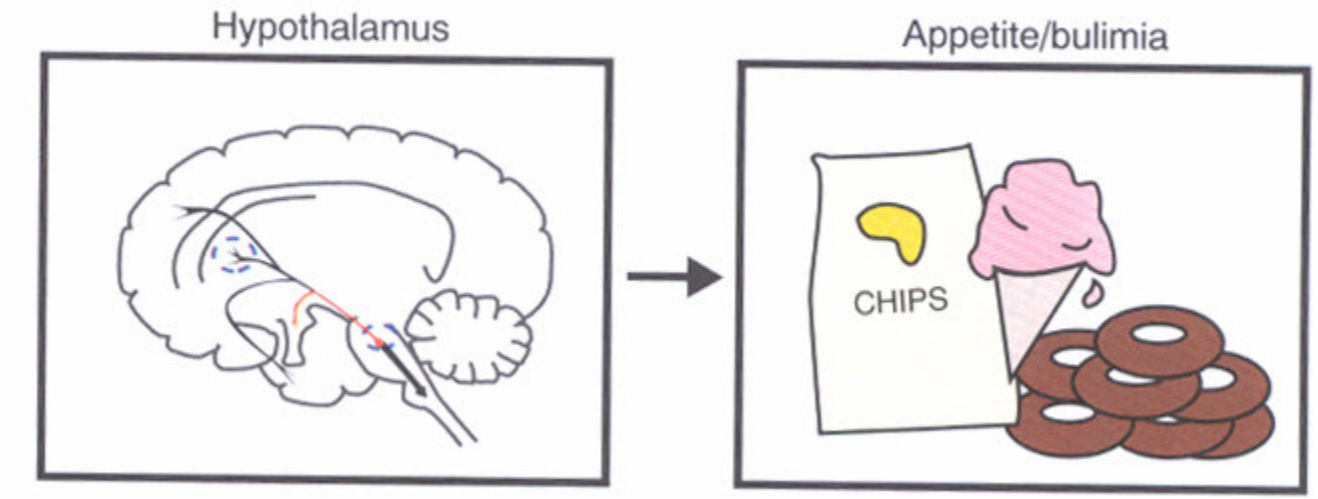
- Serotonin (5-HT) is associated with the following physiological/psychological states:
  - Mood
  - Obsessive-compulsive disorder
  - Anxiety
  - Appetite (or lack of appetite)
  - Sleep (insomnia)
  - Sexual disfunction
  - Nausea and vomiting
  - GI cramps/Diarrhea

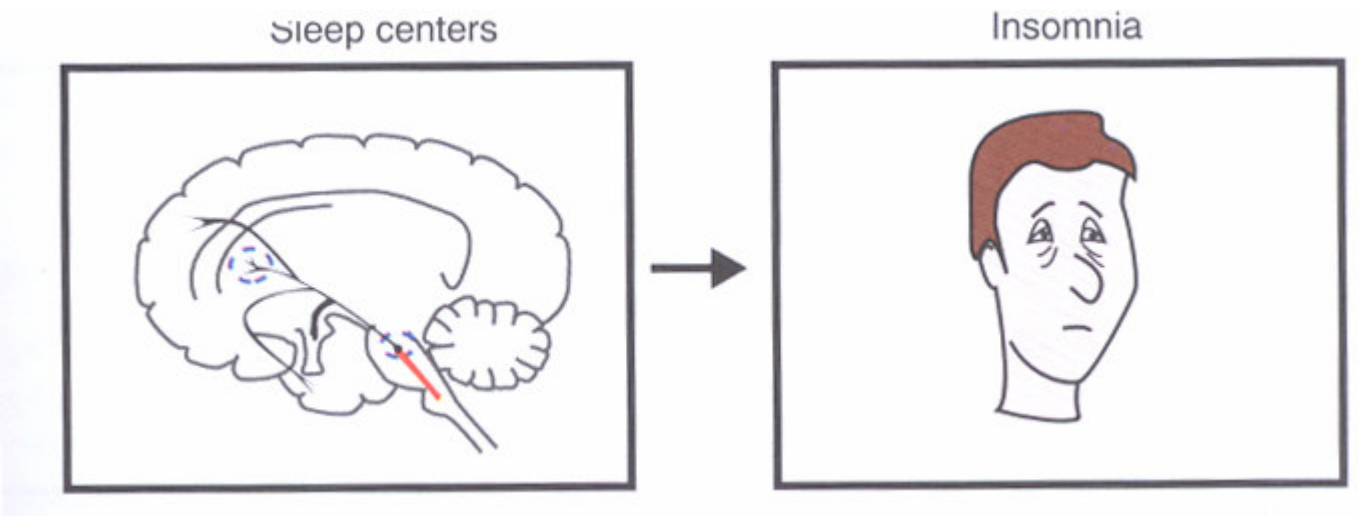

Serotonin Pathways
Raphe
Nucleus


Frontal Cortex
Mood


Basal Ganglia
Akathisia/Agitation
OCD


Limbic
Anxiety


Hypothalamus
Appetite/bulimia
CHIPS


Sleep centers
Insomnia

The Cognitive Effects of Drug Abuse

- *Brain Chemistry Affects Thoughts, Feelings, Memories, Desires, and all other Cognitive Functions;*
- *Drug abuse always has an adverse effect on brain chemistry, which, in turn, adversely affects cognitive life on a number of different levels.*

Some Cognitive Effects

- Addiction disorder
- Anhedonia (feeling bad)
- Sleep Disorder
- Information processing disorders
- Mood disorders
- Anxiety disorders
- Depression disorders
- Bipolar disorder (manic depression)
- Paranoid schizophrenia

Some Cognitive Effects (cont)

- All drugs of abuse damage the dopaminergic, norepinephrine, and serotonin pathways in the brain;
- This damage is most often irreversible, sometimes crippling, and will, at a minimum, decrease the overall quality of life for the user.